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FIFTY-FIRST ANNUAL REPORT

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

PART I.

REPORT OF THE PRESIDENT AND OTHER OFFICERS

FOR FISCAL YEAR ENDED NOV. 29, 1913.

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APPROVED BY
THE STATE BOARD OF PUBLICATION.

The Commonwealth of Massachusetts.

Massachusetts Agricultural College,
Amherst, Dec. 2, 1913.

To His Excellency Eugene N. Foss.

Sir: — On behalf of the trustees of the Massachusetts Agricultural College I have the honor to transmit herewith, to Your Excellency and the Honorable Council, Part I. of the fifty-first annual report of the trustees, for the fiscal year ended Nov. 29, 1913, this being the report of the president and other officers of the college to the corporation.

I am, very respectfully, your obedient servant,

EDWARD M. LEWIS,
Acting President.

REPORT OF THE PRESIDENT OF THE COLLEGE.

Gentlemen of the Corporation.

Owing to the absence of President Butterfield, and to the honor conferred upon me by your honorable body, it becomes my duty to present to you the annual report of the Massachusetts Agricultural College for the year ended Nov. 29, 1913. This I herewith submit.

A REVIEW OF THE YEAR.

Attendance.

The number of students enrolled in the four-year course this year is 542. In addition there are 24 registered as unclassified students and 39 as members of the graduate school. The increase over last year in attendance of regular four-year students is 40, or 8 per cent.; the total enrollment of students doing work of college grade is 605, an increase of 50 over the total enrollment of last year. The entering class numbers 201, this number being larger by 17 than the entering class of 1912. (See Table I.[1])

Eighty-two per cent. of the freshman class come from Massachusetts; 10 other States are represented. In spite of the fact that in 1912 a tuition fee was charged to students entering from States other than Massachusetts, the number of non-residents has in both years slightly increased. All counties in Massachusetts, with the exception of Dukes and Nantucket, are represented in the class; Middlesex County again this year sends the largest number, its proportion being slightly over one-fourth, Worcester County is second, and Essex County third. (See Table V.)

While one-sixth of the class are undecided as to their in-

[1] The following statistics and tables are found at the end of this report: attendance, legislative budget, statistics of the extension service, public speakers for the year, statistics of freshmen, entrance statistics of the freshman class, and changes in personnel of officers of the institution.

tended vocation, I am glad to say that over 80 per cent. of the entire class signify their intention of following some form of agriculture or horticulture. Over 94 per cent. of those who have stated their choice of a vocation intend to follow some branch of agriculture. Twenty per cent. of the fathers of the members of the freshman class are engaged in agriculture or horticulture; 23 per cent. are artisans; 31 per cent. are engaged in business; and 10 per cent. are professional men. Approximately one-fourth of the class come from farms; nearly two-fifths have had no farm experience whatever; the balance, while not having been brought up on a farm, still have had limited experience in farm work. The average age of the class is 18.94 years. (See Table V.)

The Commission on Economy and Efficiency and Legislative Appropriations.

The trustees presented to the Legislature of 1913 requests for special appropriations amounting to $250,000. Of this amount $210,000 represented a request for an agricultural building, and $40,000 for general improvements and repairs. The total asked for current appropriations was $300,000, the increase of $50,000 to be distributed between investigations and instruction, with an additional item for annual repairs.

In December, 1912, the Commission on Economy and Efficiency, which was established by the Legislature of 1912, sent an expert to the institution to make a thorough investigation as to the needs of the institution, business methods employed, and general matters of administration. After an exhaustive study had been made and several hearings held before the full commission it was agreed that the college should have a continuing appropriation for current expenses to cover a period of five years. The bill embodying a schedule of such appropriations was passed by the Legislature. A summary of the provisions of this bill will be found in Table II.

On recommendation of the Commission on Economy and Efficiency the Legislature appropriated about $80,000 for additions and improvements at the college. The principal items were those for an addition to French Hall, $35,000, an infirmary, $15,000, improvements, $26,000. (See Table II.)

Commencement.

At the annual commencement in June, 90 seniors received the degree of Bachelor of Science, a number slightly in excess of that of 1912. The college also conferred the degree of Master of Science on one candidate. Hon. Seth Low of New York City delivered the commencement address, taking as his subject, "Agricultural Colleges." The attendance at the alumni dinner was 232.

The Major System.

The major system has been given a full year's trial, and, on the whole, has proved to be highly successful as a method of securing for the individual a more adequate training in the subject selected. After a year's trial there seems to be but few modifications desirable. The new department of microbiology now has a major, but the major in general horticulture has been discontinued. The subjects which are offered as major courses, and the number of juniors and seniors this year enrolled in each, are indicated in the table below. It should be noted that agriculture, pomology, and animal husbandry, three strictly practical agricultural subjects, have large enrollments. This table clearly shows, it seems to me, that the college is largely and definitely educating its students toward practical agricultural vocations.

Subject.		Seniors.	Juniors.
Agriculture,	24	8	16
Agronomy,	3	2	1
Animal husbandry,	21	12	9
Dairying,	5	2	3
Poultry husbandry,	4	2	2
Horticulture,	2	2	–
Forestry,	6	1	5
Floriculture,	7	3	4
Landscape gardening,	34	18	16
Pomology,	42	26	16
Chemistry,	15	10	8
Entomology,	17	8	9
Botany,	7	1	6
Agricultural education,	7	3	4
Microbiology,	4	–	4
Total,	201	98	103

New Appointments.[1]

The more important appointments of the year are those of F. H. H. Van Suchtelen, Ph.D., assistant professor of microbiology; Harold E. Robbins, M.A., assistant professor of physics, as successor to Mr. Chester A. Butman; Hubert D. Goodale, Ph.D., as research biologist in poultry husbandry and Miss Laura Comstock, extension professor of home economics.

Assistant Professor Van Suchtelen received his university education in Germany, receiving the degree of Doctor of Philosophy from the University of Göttingen. Subsequently, he came to America and served at the Michigan Agricultural College as teacher and investigator. Dr. Van Suchtelen is a student and investigator of high rank, and his addition to our faculty is a valuable one.

Assistant Professor Robbins is a graduate of Trinity College (Hartford), and has pursued postgraduate study at Yale University. He has had a successful experience as a teacher, both in high school and in college work.

Dr. Goodale graduated from Trinity College (Hartford) in 1904, and then pursued graduate study at Columbia University, earning the degree of Doctor of Philosophy at that institution. He has had several years' experience in practical work and as an investigator in experimental evolution.

Miss Comstock is a graduate of Buffalo, N. Y., Normal School and of Pratt Institute. She has had several years' experience as a teacher, and since 1906 has been professor of home economics at the University of Maine. Her engagement at this institution as extension professor of home economics, meets a long-felt want, and will supply instruction for which there is great need and general demand.

Resignations.[1]

During the year Prof. Edward A. White, head of the department of floriculture, was elected to a similar chair at Cornell University. The opportunity was an attractive one, and Professor White decided to accept the position. Professor White's resignation represents a distinct loss to the Massachusetts

[1] A complete list of the resignations and of new appointments during the year will be found in Table VII.

Agricultural College, and it will be difficult to secure a successor who will develop the department and carry on the work as satisfactory as did he. Professor White came to the institution in 1907, and at once undertook the organization of a department of floriculture. At the time of his resignation it is one of the strongest and best equipped departments in the institution; indeed, it is doubtful if any college in the country has a stronger department of floriculture.

Changes in Board of Trustees.

I regret to have to report the retirement of Mr. M. F. Dickinson from our Board of Trustees. His resignation was submitted early in 1913, and was due to continued ill health. Mr. Dickinson became a member of the Board of Trustees in 1905, and was reappointed by Governor Foss in 1912. During his service on the Board of Trustees, Mr. Dickinson took an exceptionally active interest in all questions which came before the Board for consideration. His advice was frequently sought, and his opinions always had much weight with the other members of the Board. It is with deep sense of the loss sustained by the college that we report this resignation. Mr. Dickinson's successor is Mr. George P. O'Donnell of Northampton.

The new classification of stenographers and clerks, which your honorable body established last June, has worked thus far, I am glad to say, with little or no friction, and I see no reason to believe that it will not continue to work smoothly and satisfactorily.

Last April President Butterfield left the college to serve as a member of the United States commission to investigate and study in European countries co-operative farm financing. He returned to the campus in August and remained till the middle of October, when again he left on the leave of absence which extends till next May. It is needless for me to try to say how much the faculty miss his guidance and inspiration, and how much they hope that his well-deserved furlough may be fully enjoyed. We shall all be glad to welcome him back again.

It is a great pleasure for me to report that ever since the president's departure for Europe last April, the multiplicity of details that infest the president's office has been most effici-

ently handled by Mr. Ralph J. Watts, the president's secretary. And it is equally as great a pleasure for me to report that the burdens of the president's office have in a large part been willingly and cheerfully shared by my loyal colleagues on the faculty. The whole-hearted support and the generous co-operation of my fellow workers has made my task in many ways much easier than I anticipated.

Scarlet Fever.

Last January, just before the midyear examinations, the scarlet-fever epidemic, which brought suffering and gloom into many homes in the Connecticut valley, broke out within our college walls. It came upon us without warning, and in a moment brought the utmost dismay and sorrow into our college home. Twenty-five of our students were afflicted, and of those four failed to survive. Our dead friends and brothers were Edward Woodman, Jr., Portland, Me., class of 1915; Rutherford S. Treat, Seymour, Conn., class of 1916; Warner H. Burt, Longmeadow, Mass., class of 1916; T. Vincent Cannon, Newton, Mass., short course.

They were all splendid fellows, and their precious memories still abide to bless and to inspire us. Our earnest sympathy will never fail to go out to their sorrowing parents and relatives.

The suddenness of the attack and the comparatively large number of students affected, found the college almost entirely unprepared to cope with the situation. But the lack of preparation and inadequate equipment were in a great measure met by the energy, the prompt action, the willing self-sacrifice, and the whole-hearted co-operation of the entire community. Every one turned in and helped. The State authorities were here as soon as possible, the Amherst College infirmary was immediately and generously at our disposal, the Kappa Gamma Phi House was converted into a hospital and the Kappa Sigma House into a detention home; the nurses and physicians of the community responded with alacrity to the great need. The expedition with which the college and its friends met the situation mitigated greatly the results of the disease, and our indebtedness to friends within and without is in no measure suggested by the depth of our gratitude.

The epidemic was the most serious in the history of the college. The State Board of Health, in conjunction with the college, made a most careful investigation, but without avail. No one could point to a clear and definite cause, and it will probably never be known. Though a lesser item in the sad story, it will not be out of place to mention that the expense incurred was approximately $4,500. This was borne completely by the college.

Lectureship on World Politics.

On October 1 the trustees authorized an annual lectureship on "World Politics," — the first lectureship of its kind established in this country. At the same meeting Mr. R. L. Bridgman of Boston was invited to deliver the first series. The choice was a most happy one, for few scholars, if any, have studied certain phases of this great subject with more thoroughness and enthusiasm than has Mr. Bridgman. At this writing, two of these lectures have been delivered and they have been heard by large and appreciative audiences.

Improvements and Repairs.

Numerous improvements and repairs were made during the summer. The addition to French Hall, for which an appropriation of $35,000 was granted by the last Legislature, was started about the middle of July. The contractors were unable to secure the terra cotta trimmings, and accordingly not much progress was made until the latter part of October. Since then the work has gone forward rapidly, and the building will be completed during the coming year.

The principal improvements made during the summer were the macadam road extending from the entrance to the college grounds on the county road to the chapel, a 6-foot granolithic walk from the entrance to the grounds on the Stockbridge road to the old Durfee range of greenhouses, and a 6-foot walk adjoining the present granolithic walk east of the chapel and continuing to the stone bridge. Small strips of walk were constructed at Draper Hall and at Flint Laboratory. In addition, numerous cinder paths were made and some of the old tar walks were resurfaced. The dormitory rooms in South

College were thoroughly renovated and put in first-class condition. The rooms in North College were all repainted. The greenhouse at the experiment station was repaired.

The Year in the Departments of Instruction.[1]

In the Division of Agriculture. — Owing to an increase in the number of students, the work in the different departments of the division of agriculture has increased during the year. This makes the need for suitable classrooms and laboratories most urgent. All five of the departments of the division, as well as the department of microbiology, are now crowded into Flint Laboratory, which was designed for the work in dairying only. This greatly hampers the work of all the departments and decreases the efficiency of the instruction given; laboratory work in some departments has to be omitted altogether. It seems incredible that the people of Massachusetts will longer delay furnishing adequate facilities for departments whose work touches so closely and so vitally the interests of the practical farmer. In addition to the work of instruction, the demands made upon these departments for extension work are constantly increasing. There are also many problems of the practical farmer calling for solution that need the attention and investigation of every department of the division.

The work of the department of agronomy has increased rapidly, and a graduate assistant, giving half his time to the department, has been secured. The most important needs of the department are laboratory facilities for work in soils, fertilizers, and field crops.

During the past year the department of animal husbandry has assumed the responsibility for the selection, care, and management of the live stock on the college farm. A good three-year-old Percheron stallion and two young bulls of excellent breeding have been purchased.

After using Flint Laboratory for about a year, the department of dairying pronounces it most satisfactory for the purpose of instruction. The department is now clarifying and pasteurizing all milk used at the college dining hall, thus making the supply an excellent one.

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[1] The directors and heads of divisions were asked to submit a résumé of the work which had been conducted under their direction during the year, and these statements have been freely utilized in the present report.

A research biologist has been added to the staff of the department of poultry husbandry. The work of this trained investigator cannot fail to be of great service to the poultrymen of Massachusetts. Other buildings of .the department have been finished, including two small buildings for storage and a colony breeding house. More land for experimental purposes is needed.

In the department of farm administration an extension to the young stock barn and a bungalow for farm help, built during the latter part of the year, should be mentioned. Plans for a piggery to be built in the spring are also being prepared. Modern tools of the different types for demonstration purposes are urgently needed.

In the Division of Horticulture. — The work in this division has developed in a normal fashion along lines previously adopted. The division has suffered during the year by the resignation of Prof. Edward A. White, as head of the department of floriculture. The much-needed addition to French Hall is now being constructed; when completed this building will be one of the most attractive structures on the campus, and will provide several additional classrooms and laboratories for the departments there housed.

The head of the division of horticulture makes the following statement: —

The most serious and fundamental problem which we face is that of the college curriculum. The feeling is unanimous among the members of the horticultural staff that the work should be greatly intensified and substantially improved in all its technical aspects. We believe that it should be given more attention in the curriculum, and that it is very desirable to have some work, very carefully organized, advanced to an earlier position in the four-year course. We believe, also, that provision should be made at once, by a somewhat radical readjustment, for technical instruction throughout the summer. It hardly seems reasonable that we should longer continue to close our work to our four-year students during that portion of the year when subjects of technical importance are most accessible.

In the Division of Science. — During the collegiate year the work of this division has progressed along the usual lines. A certain amount of revision and rearrangement of the courses previously offered has been made, but nothing affecting general

policies; the changes have been for the purpose of securing greater efficiency. An examination of the statements supplied by the different departments indicates that in some cases more room is needed for class and laboratory work. The department of chemistry is in pressing need of a new building. The most important problems in this division at the present time seem to be (1) the necessity for a closer co-ordination of the work in the different departments of the division, and (2) a determination of the relation of the work when formulated to that demanded by other divisions.

In the Division of the Humanities. — The head of this division reports progress in the further organization of the departments under his direction. The efficiency of the work which can be done under the present conditions is greatly impaired because the various departments are scattered about the campus; in some cases a department has no headquarters. The need of a properly equipped library is felt very keenly by all members of this division. Inasmuch as certain proposed changes are being advocated in the course of study, it is felt that the teachers in this division are not yet able to do their best work.

In the Division of Rural Social Science. — The instructors in this division continue to hold the opinion that a major in rural social science should be offered for the benefit of those students desiring to specialize in this work. The most pressing need of the division is for adequate and convenient housing facilities. At present the various departments are scattered about the campus in buildings provided for and occupied by other departments. The most efficient work cannot be carried on under these conditions.

In the department of agricultural economics the work has developed along lines already established. From April to July the head of this department accompanied the federal commission to investigate rural credit and co-operation in Europe. An investigation has been conducted relative to the facilities for farm credit in Massachusetts.

In the department of agricultural education the promotion of boys' and girls' agricultural clubs has become a prominent feature. (Statistics relative to the enrollment in this work are found in Table III.) The department is also endeavoring to develop closer relations with the public schools in the matter

of preparing teachers of agriculture and related sciences. There is at this time under consideration a plan whereby the students preparing for that work may, under expert supervision, obtain practice in teaching. The demand for agricultural teaching in secondary schools has become much greater than the supply of qualified persons.

In the department of rural sociology a prominent aim is the promotion of interest in rural-life problems. Surveys of social conditions in near-by towns form a part of the instructional work. One such survey was completed during the past year; this survey work is done in part by graduate students. There is an increasing number of men coming into the department with the specific purpose of fitting themselves for some form of social service.

In the Library. — There were 2,969 volumes added during the year, making a total of 41,069 volumes on hand. Of this number, 10,860, or more than 25 per cent. of the entire library, have been added during the past five years. The new card catalogue in process of making contains cards for the 17,278 volumes re-catalogued, and the 7,593 new volumes catalogued since April 1, 1910. One of the most important and gratifying events of the year was the decision of the Carnegie Institution of Washington to place the college library upon its "omnia list," to receive all of its publications without charge. This is a recognition of the work the library is doing and the place it fills in this community. The Academy of Natural Sciences of Philadelphia has recently taken similar action. The regular library extension work continues and was supplemented this year by the publication of five library leaflets listing the best books for fruit growers, poultrymen, dairymen, vegetable gardeners, and farm women.

The very urgent need of this department, and, in fact, the need of the institution, is for a new library building. The climbing of stepladders in search of books, the eager hunt for unoccupied chairs, and the crowded aisles are grave hindrances to real, serious study. Office and workroom accommodations are discouraging; faculty and graduate school workers are crowded in among the students, and the reading room is grossly inadequate. As long as the library continues in such straightened circumstances, just so much will our students lose in the

way of proper working accommodations in what ought to be the finest and best working laboratory on the campus. More than this, we feel that a new library building would do much to stimulate real spirit for study and to create a better academic atmosphere.

In the Department of Physical Education and Hygiene. — The work of the department during the past year has been conducted along the following lines: —

1. The physical examination of each freshman, to ascertain the condition of health and physical development, and to detect defects which may exist, especially in sight, hearing, heart, and lungs. Each person thus examined is advised as to the form of exercise best suited to his individual condition.

2. The freshman class receives instruction in physiology and personal hygiene in a course of lectures given by the physical director.

3. During the winter months the department requires three hours of physical exercise per week of each member of the three lower classes. Those men who have been found by examination to be physically normal are permitted to elect one of the several athletic activities; those who have been found to be below normal physically are given individual instruction. Walking trips may be substituted for physical exercise in the gymnasium; during the past year from 75 to 100 students elected this form of exercise.

The work of the indoor classes of from 30 to 40 men consists of gymnastic exercises and such games as basket ball and indoor baseball. The physical director is general manager of athletics, supervising the arrangements for contests with other colleges, buying the supplies for the teams, assisting in the coaching and having final control of the conduct of players and games. During the past year the trustees have created a body for the control of athletics, and for the first time are giving definite recognition to these activities. The past year has seen a great increase in interest in athletic recreation, and the records show that over 40 per cent. of the students participated in one or more sports regularly and under official supervision.

In the Department of Military Science. — Owing to the increased number of students more companies have been formed,

so that we now have two battalions of four companies each and a band. The organization is that of the regular infantry of the United States army, and the work is along the lines of work done by infantry.

Great interest is still maintained in the intercollegiate rifle contests. This year the indoor team won the eastern league championship, but the University of West Virginia, winner of the western league championship, defeated our team for the college championship. On the outdoor range we won the college championship for the United States by the score of 825, 6 men shooting 10 rounds each at 200, 300, and 500 yard ranges. Harvard was second with 791, our previous record score. In the last four years this college has won the indoor championship three times and second place once, and has made a like record on the outdoor range.

Four hundred and fifty men have drilled during the year, 16 of them being of the senior class, with whom drill is elective. Fourteen of the last graduating class were reported to the Adjutant General of the army and the Adjutant General of the Commonwealth of Massachusetts as being proficient in drill, and recommended for commissions in the militia of the volunteer army.

This fall there has been started a signal corps detachment; this will be a great help in the field work of the regiment. The band is in excellent condition and deserves to be continued and better equipped with instruments. The uniform has been increased and changed; it now consists of olive-drab cap, blouse, trousers, leggings, shirt, and campaign hat. This is an improvement over the old blue uniform. This uniform is of the very finest quality and costs $17.85. At the annual inspection, May 21, 1913, made by the officer sent by the War Department, we were given a most excellent report on the work done.

The Graduate School.

The total number enrolled by registration during the year 1912–13 was 28; the total number registered in the fall of 1913 thus far is 39. At the beginning of this college year a tentative organization of the school was accepted by the Board of Trustees. It is felt that the growth is as rapid as is com-

patible with the best interests of the department. Furthermore, it seems advisable that we should keep the numbers within certain limits. The ambition of the director is to cluster about every capable teacher on the campus one, two, or three graduate students. To go beyond this number would mean more than many of the departments can effectively care for. The needs of the graduate school are largely departmental, and are of such a nature that only time can supply. The important problem is to turn out well-equipped and effective men. By this is meant men who are sympathetically and broadly trained in fundamental education, and intensely trained in some special field for some particular pursuit.

The Year in the Experiment Station.

It is with pleasure that we welcome back to active service Dr. William P. Brooks as director of the experiment station. His prolonged leave of absence restored him to normal health and strength. During his absence the work of the experiment station was very efficiently conducted by Mr. Fred W. Morse.

Agricultural Department. — The leading lines of experimentation have followed very closely the plans mapped out in former years, and have had to do chiefly with the specific effects of various fertilizer materials and combinations and methods of using manure. Investigations along these lines have been carried through to a successful conclusion. Owing to a low temperature when the trees were in bloom, the Graves orchard produced no fruit this year. The experiment station orchard, on the other hand, yielded its heaviest crop. The fertilizer work with asparagus in Concord has been continued with satisfactory results. The cranberry bog of the substation at Wareham has given a very large crop, yielding about 1,250 barrels; the sale of the crop will undoubtedly bring the station an income of at least $6,000. The experiment results have been clear and decisive in certain important points, chiefly throwing light upon methods of repelling the attacks of injurious insects. The weather observations of the substation, in co-operation with the United States Weather Bureau, promise to prove of much value in enabling Dr. Franklin to forecast probability of frosts.

Department of Plant and Animal Chemistry. — Inspection

Work: The work of this department has been conducted the past year without any interruptions. The inspection work of the department shows a gradual increase. Approximately 1,300 samples of fertilizers and 902 samples of cattle feeds have been collected and examined. During 1912, 6,056 pieces of glassware were tested, the machines in 180 creameries and milk depots were inspected, and 33 men were examined for proficiency in operating the test; 27 of these were given certificates. About the usual number of samples of water, milk, soils, manurial residues, and other materials of an agricultural nature have been analyzed during the year.

Cow-testing Work: Three men have been employed continuously in making yearly tests of Guernsey, Jersey and Ayrshire cows, and during the year 13 men have been employed at different times on Holstein-Friesian tests.

Miscellaneous Work: During the year this department has published three bulletins, — one on the inspection of commercial fertilizers, another on the inspection of commercial feedstuffs, and a third on the cost of milk production.

New Work undertaken: Studies have been undertaken of the relative value of phosphatic slag as a source of phosphoric acid, also the relative value of Stonemeal and New Mineral Fertilizer as compared with standard mixed fertilizers.

The various lines of work in progress require the constant services of ten chemists, one laboratory helper, one inspector, two clerks, one assistant in animal nutrition, besides numerous men in connection with the cow-testing work.

Substantial progress has been made in methods for the determination of the composition of butter fat and of the effect of food groups in modifying the butter-fat molecule. Progress has also been satisfactory in a study of the effect of fertilizers upon asparagus and cranberries. Work has been more particularly confined to the composition of asparagus tops and to cranberry bog water.

Department of Vegetable Pathology and Physiology. — The amount of work coming to this department continues to increase so that at present the need for another assistant is keenly felt. During the past year much time has been spent by experts in the department traveling about the State investigating the various outbreaks of plant diseases. Much work

has also been done in testing seeds for farmers in the vicinity of the college.

The head of the department feels that a great deal more work should be done on soil sterilization and the cause of its effects on plant growth, together with the discovery of improved methods. New methods of treating plant diseases should be worked out with the idea of eliminating spraying. The chestnut blight should be studied from the remedial point of view. The subject of electricity as related to the stimulation of plant growth is by no means understood, and in the future a great deal of a practical nature will be learned. There has recently been found in the laboratory a 70 per cent. increase in nitrogen fixation by the stimulation of atmospheric electricity, and outside of the necessary apparatus this can be gathered without expense.

Horticultural Department. — The year's work in the division of horticulture has gone on without special incident so far as the experimental problems are concerned. Dr. Shaw has put under way very important experiments in the mutual influence of stock and scion, and the Tuxbury land is being developed for the special purpose of this experiment. The most immediate and pressing needs are for additional funds to take up the work in plant breeding and to develop lines of experimental work in floriculture and market gardening.

Department of Poultry Husbandry. — The year has been marked by the establishment of experimental work as a separate division of this department, with a man devoting all his time to investigational work. The investigations thus far have been directed toward an analysis of the flock of standard-bred Rhode Island Reds, in respect to individual differences in fecundity, fertility and hatchability of eggs, and vigor of offspring. The head of this department feels very keenly the need of additional land, additional facilities for housing poultry, and additional labor.

Veterinary Department. — The work of the department has gone forward in accordance with the plan which has prevailed for the last few years. The members of this department are very desirous to undertake investigational work in pathology.

Department of Entomology. — The following notes indicate the work conducted in this department during the year: —

(*a*) Causes of burning by Arsenicals: Over 4,000 different experiments have now been made, and the results give much of interest and value.

(*b*) Importance of Wasps as Parasites: During the summer an investigation of everything known on this subject in Europe, so far as concerns our American wasps, has been completed, and has given a firm basis for further research on this problem.

(*c*) Dates of hatching of our common scale insects.

(*d*) Control of the Onion Maggot: Last year it was demonstrated that methods recommended hitherto are either worthless or are inapplicable because of cost. This year entirely new methods have been tried, some of which have given very promising results.

Additional expert assistance is needed in this department to meet additional demands made upon it for expert work.

Department of Meteorology. — The work of the year has necessarily followed the routine of previous years; co-operation with the Weather Bureau has been continued as usual, and the regular monthly issue of the weather bulletin has been continued.

The Year in the Extension Service.

The organizing of the extension service during the past year has gone forward on the plans previously adopted. After considerable investigation of the methods in vogue in other Land Grant colleges, it is found that the type of organization which we have been trying to establish in this college is in accord with that of other leading institutions. More effort has been placed on correlating the work of the extension service with the several departments and divisions of the college, and establishing proper co-operative relationships with other agencies in the State interested in rural development, than in trying to establish new forms of work, no matter how badly these were needed.

The appropriation from the State, available for the current year, has been $50,000. With this increased money it has been possible to add new members to the extension service staff, and to take up certain lines of work recommended in former reports. A complete list of new employees is found in Table VII.

Ten Weeks' Courses. — There were 22 given in the winter school of 1913. The constantly increasing attendance, and the often-expressed satisfaction at the quality and kind of work offered, is the best indication of the value of these courses to the people of the Commonwealth. The enrollment was 153.

Summer School of Agriculture and Country Life. — This was resumed in 1913. New courses in recreation, pageantry, handicrafts, home flower growing, insects and diseases were offered in addition to those which have been given in the past. The attendance was 133.

Conference for Rural Community Leaders. — This conference was again held as a closing feature of the summer school. The same organizations co-operated with the college to make the conference a success as in the past. Many communities in this and other States are using the information, inspiration and enthusiasm received at these conferences for a more intelligent handling of their problems.

Boys' Agricultural Camp. — For the first time in its history the college conducted a boys' agricultural camp. These boys, selected from rural communities, were taught agriculture, clean sportsmanship, hygiene, photography, and recreation. The attendance was 33. In order that more boys may be reached, a succession of these camps is being planned in connection with the summer school of 1914.

Poultry Convention. — This year the time of holding the poultry convention was changed from March to July, with the result that the largest number of poultry men ever gathered together at one time in this country was present.

School for Tree Wardens. — This was offered for the first time in 1913. Its purpose was to acquaint those in charge of trees with the best methods of care, use of spraying materials, and of apparatus. The attendance was 44.

Fair Exhibits. — For a long time there has been a demand for a somewhat extensive educational exhibit to be used at agricultural fairs throughout the State. During the past year the extension service has assembled such an exhibit. A large tent was purchased and exhibits were made at seven of the more important fairs. From eight to fifteen demonstrations were given at each fair by officers of the college.

One of the best features of the educational work done by the college this year was the continuation of the boys' stock judging contests at the fairs. Fifteen such contests were held, 126 boys taking part. This form of work has certainly proved to be a liberal education to the boys participating.

College men acted in the capacity of judge 77 times during the year, most of this work being done at the fairs during the fall season. At some places there was only a limited amount of work done; in other places the entire amount of judging at the fair was done by the men in question.

Extension Schools. — The extension schools have been continued in 1913. Eight schools were held in various parts of the State; these schools are becoming more popular each year, and the extension service is unable to conduct nearly all that are requested.

Automobile Demonstration Work. — During the past few months an automobile demonstration truck has been sent about the State in charge of a trained agriculturist. This man spends several days in a community, visiting farms, giving demonstrations, and answering questions on agricultural topics.

Statistics of extension service activities will be found in Tables I and III.

THE IMMEDIATE NEEDS OF THE COLLEGE.

In previous reports to the corporation President Butterfield has set forth in his usual thorough and comprehensive manner the general and special needs of the institution. I can do no better, therefore, than to quote him quite freely on this topic. In last year's report (page 23) he writes: —

> Fundamentally, the need of increased appropriations, both for maintenance and for buildings, is due in part to the growth of the college in number of students, but also in part to the increased activities of the college made necessary by the rapidly enlarging field of agricultural research, instruction and dissemination. Our understanding of the rural problem in Massachusetts is constantly broadening, and as our conception of the problem broadens, the necessity of broadening the work of the college in order to help solve the problem also develops.

Heretofore the larger part of this section of the annual report has had to do with the need of increased appropriations for

maintenance and current expenses. Hereafter, however, the president will be relieved not only of this task but also of the great labor and anxiety incident to the passage through the Legislature of this part of the appropriation bill. The Legislature of 1913, as I have said before (page 6), provided an annual sum for the next five years, graduated in character, which will probably meet the situation during that time in a fairly satisfactory manner. The annual sums granted by the Resolve of the Legislature are: —

1914,	$280,000
1915,	303,000
1916,	325,000
1917,	341,000
1918,	362,000

While this wise and fairly generous action disposed of one phase of our needs in a manner such as not to vex us soon, and such as makes it unnecessary to refer to them now, the need for buildings and additions, let me emphasize, is to-day greater than ever. The college has grown tremendously in the past three years. We have over 600 students doing regular work on the campus this fall, and the building equipment is entirely inadequate to meet their needs in an effective way. In order to do this, and to be equally as well equipped as other institutions of a similar size, we should have without delay the following buildings: an agricultural building, a new auditorium, a new library, a new chemical building, a good-sized recitation building, a gymnasium and drill hall, and three or four dormitories. These, I say, should be on the grounds now, but under the present financial condition of the State I realize that it is a sheer impossibility to get them, and worse than futile to try.

The trustees, fully realizing both the need and the difficulty, decided at the meeting of October 21 to present a request to the Legislature for only such buildings as were most necessary to relieve the present slim and inadequate equipment, and for such an appropriation as could reasonably be expected the Legislature would approve. The budget for special appropriations to be presented to the Legislature of 1914 is as follows: —

Agricultural building, including equipment,		$210,000	
To be available in 1914,	$87,500		$87,500
To be available in 1915,	122,500		
Student dormitory,			35,000
Minor additions,			10,000
			$132,500

Appropriations for Special Purposes.

An Agricultural Building. — This building has been asked for twice before, and in the report of last year the president says: —

The main item which the trustees desire to press before the Legislature this winter as a special appropriation is one of $210,000 for an agricultural building. I cannot do better than to quote from my report of a year ago concerning the need of this building: —

Although the college has been open to students nearly forty-five years, it has never had a building devoted specifically to agricultural teaching.

Practically every agricultural college in the country finds it necessary and desirable to make such a building one of the most important on the campus.

The rapid increase in our agricultural students has crowded the agricultural departments out of their old quarters. It is almost impossible to do efficient teaching under present conditions.

The winter short-course students are also inadequately provided for.

The proposed building will have three stories and a basement, and contain offices, classrooms and laboratories for the departments of farm administration, agronomy, animal husbandry and agricultural engineering. It is proposed to erect a fireproof building and to equip it in harmony with the recent developments in these lines of work.

To this statement should be added and emphasized the fact that the building as at present planned will also include an auditorium. This is a very important consideration, for we have no room or building on the campus that will seat all of our students at one time. On this account the unclassified and the graduate students have not been permitted to attend any general college exercises.

Dormitory, $35,000. — This building has been asked for for some years. If it was ever needed it is needed now; the present dormitories provide for only one-tenth of our students. The number of rooms in private houses within a reasonable distance of the college is very limited; a large part of our students are

living at least a good mile from their classrooms. Moreover, these rooms can be secured only at high rents, — rents in many instances prohibitive to poor students earning their way through college. As I said before, we really should have at least three dormitories without delay, in order to meet properly the present situation. The dormitory the trustees are asking for will accommodate 50 men, and will be managed in such a way that students can secure good living accommodations at a comparatively reasonable cost. It is also expected to bring a fair return on the investment.

Additions, $10,000. — One-half of this sum, or $5,000, is desired for the extension of granolithic walks and of macadam roads; the other half, or $5,000, is desired in order to provide adequate toilet arrangements, suitable storage for coal and vegetables, and larger refrigerating facilities in the basement of the dining hall. Both needs are imperative.

Respectfully submitted,

EDWARD M. LEWIS,
Acting President.

Statistics of the College.

Table I. — *Attendance.*

	Registration Nov. 30, 1912.		Registration Nov. 29, 1913.	
Senior class,	91		98	
Junior class,	102		103	
Sophomore class,	125		140	
Freshman class,	184		201	
	502		542	
Graduate students,	22		39	
Unclassified students,	31		24	
Total doing work of college grade,		555		605
Short courses: —				
Winter school,	131		153	
Poultry course,	80		–	
Apple-packing school,	40		25	
Beekeepers' course,	10		6	
Summer school,	–		133	
School for tree wardens,	–		44	
		261		361
Total,		816		966

Table II. — *Legislative Budget, 1913.*

Items.	Amount asked.	Amount granted.
1. Special appropriations: —		
Agricultural building, including equipment,	$210,000 00	–
General repairs and improvements,	40,000 00	$26,000 00
Addition to French Hall,	–	35,000 00
Infirmary,	–	15,000 00
Architect's fees,	–	4,202 11
	$250,000 00	$80,202 11
	Increase asked.	Total asked.
2. Current Appropriations: —		
Administration,	–	$30,000 00
Maintenance and equipment,	–	80,000 00
Investigation,	$15,000 00	30,000 00
Instruction,	20,000 00	95,000 00
Short courses and extension,	–	50,000 00
Repairs,	15,000 00	15,000 00
	$50,000 00	$300,000 00

Amount granted by the Legislature (Five-year Period).

	1914.	1915.	1916.	1917.	1918.
Administration,	$30,000	$31,000	$32,000	$33,000	$34,000
Maintenance and equipment,	85,000	90,000	95,000	100,000	105,000
Improvements,	8,000	10,000	10,000	10,000	10,000
Investigations,	20,000	25,000	30,000	35,000	40,000
Instruction,	85,000	90,000	100,000	105,000	115,000
Short course and extension work,	50,000	50,000	50,000	50,000	50,000
Graduate school,	2,000	2,000	3,000	3,000	3,000
Additional land,	–	5,000	5,000	5,000	5,000
	$280,000	$303,000	$325,000	$341,000	$362,000

Table III. — *Statistics of the Extension Service for 1913.*

Extension Service conducted at the College.

Farmers' week,	950
Beekeepers' convention,	115
Boys' agricultural camp,	33
Conference on rural community planning,	247
Poultry convention,	362
Correspondence courses: —	
Present enrollment,	582
Courses completed or work dropped during year,	327
Total,	2,616

Extension Service conducted away from the College.

Lectures: —

Lectures at fairs: number given, 175; attendance, 3,479; Extension schools, number given, 480; attendance, 1,000; Lecture courses (4), number given, 21; attendance, 525; miscellaneous lectures, number given, 483; attendance, 39,063; approximate attendance, 44,067.

Extension schools: —	
Requests for schools,	23
Number held,	8
Enrollment,	792
Approximate attendance,	1,000
Sessions for men, 240; for women, 160,	400
Demonstration orchards: —	
Demonstration orchards: to 1913, 10; 1913, 3,	13
Renovation orchards: to 1913, 4; 1913, none,	4
Fairs: —	
Number of exhibits made,	7
Number of lectures given at exhibits,	75
Attendance at lectures,	3,479
Number of stock-judging contests held,	15
Number of contestants,	126
Number of times men acted as judges,	77
Farm visits: —	
Visits requested,	173
Visits made by demonstration auto truck,	175
Visits made by other men,	72
Boys' and girls' clubs: —	
Home and school garden: number of clubs, 212; towns represented, 212; members, 19,366.	
Agricultural clubs: number of clubs, 102; towns represented, 102; members, 447.	
Local exhibits,	11
Exhibits at fairs,	19
Traveling libraries: —	
Libraries receiving books,	37
Volumes sent out,	439
Bulletins, etc., sent out,	201

TABLE IV. — *Speakers for the Year.*

A. Speakers at Wednesday Assemblies for Year ending Nov. 29, 1913.

1912.

Dec. 11. — Prof. George B. Churchill, Amherst College, "Honor."

Dec. 18. — Mr. Arthur D. Call, Washington, D. C., "A Phase of the High Cost of Living."

1913.

Jan. 15. — Mr. George T. Powell, New York City, "Agricultural Opportunities."

Feb. 12. — Pres. F. S. Luther, Trinity College (Hartford, Conn.), "The Education of Hardship."

Feb. 19. — Rev. G. Glenn Atkins, Providence, R. I., "The Apportionment of Life."

Feb. 26. — Mr. Timothy E. Byrnes, Boston, "Character the Best Help to Efficiency."

Mar. 5. — Prof. Curry S. Hicks, Massachusetts Agricultural College, "Physical Education in Western Institutions."

Mar. 12. — Mr. Lyman Beecher Stowe, New York City, "Junior Republics."

Mar. 19. — Mr. H. B. Fullerton, Medford, L. I., "Do your Level Best."

Mar. 26. — Rev. W. H. Stebbins, Charlestown, Mass., "Fundamental Causes of Crime."

Apr. 16. — His Excellency the Argentina Minister, Dr. Romula S. Naon, "Argentina: Industrial, Commercial, Agricultural."

Apr. 23. — Mr. James P. Munroe, Boston, "What Business expects of Young Men."

Apr. 30. — Dr. Joseph L. Hills, University of Vermont, Charter Day Address.

May 14. — Mr. George D. Leavens, New York City, "Business and the College."

May 21. — Mr. Jens Jensen, Chicago, "Local Color."

June 4. — "Lessons of the Year."

Sept. 17. — Pres. Kenyon L. Butterfield, Massachusetts Agricultural College, "Lessons from Europe."

Sept. 24. — Hon. Charles E. Ward, Buckland, Mass., "Legislative Methods."

Oct. 1. — Anniversary Day Program.

Oct. 15. — Pres. Alexander Meiklejohn, Amherst College, "Scholarship."

Oct. 22. — Pres. C. H. Spooner, Norwich University, "The Book of Job."

Oct. 29. — Mr. Harry W. Laidler, New York City, "Socialism."

Nov. 12. — Pres. L. L. Doggett, Y. M. C. A. College, Springfield, Mass., "The Modern Man's Religion."

Nov. 19. — Dr. R. J. Floody, Worcester, Mass., "The Boy Problem."

B. Speakers at Sunday Chapel for Year ending Nov. 29, 1913.

1912.

Dec. 8. — Rev. Henry W. Foote, Boston, "The Aims of Higher Education."

Dec. 15. — Rev. Allen A. Stockdale, Boston, "The True Definition of Eternal Life."

1913.

Jan. 12. — Rev. Daniel C. Evans, Cambridge, Mass., "The Voice of Man and the Echo of the World."

Feb. 16. — Rev. Edward S. Ninde, Providence, R. I., "Obedience to the Heavenly Vision."

Feb. 23. — Rev. R. H. Potter, Hartford, Conn., "Prepare Ye the Way of the Lord."

Mar. 2. — Rev. F. S. Child, Griswold, Conn., "Child Welfare."

Mar. 9. — Rev. E. F. Sanderson, Brooklyn, N. Y., "The Love of God revealed through Man."

Mar. 16. — Rev. Frank W. Padelford, Boston, "The Mind of Christ."

Mar. 23. — Rev. William E. Strong, Boston, "Now and Then."

Apr. 13. — Rev. John C. Adams, Hartford, Conn., "Three Worlds in One."

Apr. 20. — Rev. Charles Stelzle, New York City, "Some Phases of the Social Problem."

Apr. 27. — Dr. L. Clarke Seelye, Northampton, Mass., "God's Building."

Nov. 9. — Rev. J. Herman Randall, New York City, "The Religion of the Modern Man."

Nov. 16. — Rabbi Stephen S. Wise, New York City, "Ideals and Idealists."

Nov. 23. — Rev. Robert Goldsmith, Chatham, N. Y., "The Temptation of every Man."

TABLE V. — *Statistics of Freshmen entering Massachusetts Agricultural College, September, 1913.*

A. Home Addresses of Students (classified by Towns and Cities).

Adams	1	Cataumet	1	Grafton	1
Amherst	10	Chartley	1	Granby	1
Ansonia, Conn.	1	Chelsea	1	Greenfield	1
Arlington	2	Chicopee	1	Hadley	1
Arlington Heights	1	Cincinnati, O.	1	Hartford, Conn.	2
Athol	1	Clinton	1	Hatfield	1
Auburndale	1	Dorchester	8	Haverhill	1
Barre	1	East Weymouth	1	Hingham	2
Belchertown	1	Elizabeth, N. J.	1	Holden	1
Bennington, Vt.	1	Everett	4	Hopedale	1
Boston	5	Fall River	3	Houlton, Me.	1
Brockton	1	Falmouth	1	Kansas City, Mo.	1
Brooklyn, N. Y.	3	Faneuil	1	Lawrence	2
Cambridge	1	Framingham	2	Leominster	1
Cape Neddick, Me.	1	Georgetown	1	Long Branch, N. J.	1

A. Home Addresses of Students (classified by Towns and Cities) — Continued.

Lowell,	1	North East, Pa.,	1	Taunton,	3
Lynn,	10	Northfield, Vt.,	1	Tewksbury,	1
Malden,	4	North Reading,	1	Townsend,	2
Mansfield,	1	Norwich Town, Conn.,	1	Turners Falls,	3
Mattapoisett,	1	Nyack, N. Y.,	1	Waban,	1
Medford,	1	Orange, N. J.,	1	Wakefield,	1
Melrose,	3	Pepperell,	1	Walpole,	2
Merrimac,	2	Pittsfield,	1	Waltham,	1
Middletown, N. Y.,	1	Plymouth,	1	Ware,	1
Milford,	1	Poughkeepsie, N. Y.,	1	Watertown,	1
Milford, N. H.,	1	Ridgefield Park, N. J.,	1	Wellesley Farms,	1
Millbury,	1	Roslindale,	1	West Acton,	1
Millis,	1	Rutherford, N. J.,	1	West Bridgewater,	1
Mittineague,	1	Sandwich,	1	Westford,	1
Montague,	2	San Juan, P. R.,	1	West Hartford, Conn.,	1
Monticello, Ky.,	1	Scituate,	1	West Medway,	1
Nantasket Beach,	1	Sharon,	1	West Newton,	1
Natick,	1	Sherborn,	1	Westport, Conn.,	1
New Britain, Conn.,	2	Shrewsbury,	1	Wethersfield, Conn.,	1
Newburyport,	2	Smiths,	1	Whitinsville,	1
Newton Center,	1	Somerville,	4	Winchester,	1
Newtonville,	1	Southborough,	1	Winthrop,	1
New York City,	1	Southbridge,	1	Wilkes-Barre, Pa.,	1
Norfolk,	1	South Carver,	1	Woburn,	1
North Adams,	1	South Framingham,	1	Woods Hole,	1
North Bennington, Vt.,	2	South Hadley Falls,	1	Worcester,	7
North Beverly,	1	Springfield,	6	Yalesville, Conn.,	1
North Brookfield,	1	Sunderland,	2	Yonkers, N. Y.,	1

B. Home Addresses (classified by States).

	Number.	Per Cent.		Number.	Per Cent.
Connecticut,	10	4.97	New York,	8	3.98
Kentucky,	1	.50	Ohio,	1	.50
Maine,	2	1.00	Pennsylvania,	2	1.00
Massachusetts,	165	82.08	Porto Rico,	1	.50
Missouri,	1	.50	Vermont,	4	1.99
New Hampshire,	1	.50			
New Jersey,	5	2.48		201	100.00

C. Home Addresses (classified by Counties of Massachusetts).

	Number.	Per Cent.		Number.	Per Cent.
Barnstable,	4	2.42	Middlesex,	44	26.67
Berkshire,	3	1.82	Nantucket,	–	–
Bristol,	8	4.85	Norfolk,	8	4.85
Dukes,	–	–	Plymouth,	9	5.45
Essex,	19	11.51	Suffolk,	16	9.70
Franklin,	8	4.85	Worcester,	21	12.73
Hampden,	8	4.85			
Hampshire,	17	10.30		165	100.00

D. Nativity of Parents.

	Number.	Per Cent.
Neither parent foreign born,	150	75.00
Both parents foreign born,	31	15.50
Father (only) foreign born,	10	5.00
Mother (only) foreign born,	6	3.00
No statistics,	4	2.00
	201	100.50

E. Education of Father.

	Number.	Per Cent.
Common school,	94	47.00
High school,	56	28.00
Business school,	13	6.50
College or university,	30	15.00
No statistics,	8	4.00
	201	100.50

F. Religious Census.

	Membership.		Preference.		Totals.	
	Number.	Per Cent.	Number.	Per Cent.	Number.	Per Cent.
Baptist,	22	11.00	4	2.00	26	13.00
Catholic,	21	10.50	–	–	21	10.50
Congregationalist,	36	18.00	28	14.00	64	32.00
Episcopal,	26	13.00	1	.50	27	13.50
Hebrew,	5	2.50	1	.50	6	3.00
Methodist,	12	6.00	7	3.50	19	9.50
Presbyterian,	8	4.00	2	1.00	10	5.00
Unitarian,	10	5.00	7	3.50	17	8.50
Universalist,	3	1.50	3	1.50	6	3.00
Miscellaneous,	1	.50	4	2.00	5	2.50
	144	72.00	57	28.50	201	100.50

G. Occupation of Fathers.

	Number.	Per Cent.
Agriculture and horticulture,	40	20.00
Artisans,	46	23.00
Business,	62	31.00
Deceased or no statistics,	23	11.50
Miscellaneous,	6	3.00
Professional,	21	10.50
Retired,	3	1.50
	201	100.50

H. Intended Vocations of Students.

	Number.	Per Cent.
Agriculture or horticulture (practical),	126	63.00
Agriculture or horticulture (professional),	35	17.50
Miscellaneous,	3	1.50
Professions,	6	3.00
Undecided or no statistics,	31	15.50
	201	100.50

I. Farm Experience.

	Number.	Per Cent.
Brought up on a farm,	48	24.00
Not brought up on a farm and having had no, or practically no, farm experience,	76	38.00
Not brought up on a farm, but having had some farm experience,	74	37.00
No statistics,	3	1.50
	201	100.50

J. Miscellaneous Statistics.

Average age,	18.94 years.
Number applying for student labor,	110 (55 per cent.)
Number boarding at college dining hall,	165 (82.5 per cent.)

Table VI. — *Entrance Statistics of Freshman Class.*

Number of applications,			332
Admitted,		228	
Matriculated,	201		
Failed to report,	27		
Total,		228	
Rejected,		104	
Total,			332
Admitted on certificate,			86
Admitted on examination,			17
Admitted on certificate and examination,			98
			201
Admitted without condition,			122
Admitted with condition,			79
			201

Table VII. — *New Appointments.*

In the Academic Departments.

Position.	Name.	Institution from which graduated and Degrees.
Graduate assistant in agricultural economics,	Charles G. Baird,	University of Kansas, A.B., 1911; University of Wyoming, A.M., 1913.
Instructor in zoölogy and geology,	Frank N. Blanchard,	Tufts College, A.B., 1913.
Graduate assistant in chemistry,	Henry L. Brown,	Massachusetts College of Pharmacy, Pharm.D., 1911; University of Maine, B.Sc., 1913.
Graduate assistant in microbiology,	Ernest L. Davies,	Toronto University, B.S.A., 1913.
Instructor in market gardening,	Bert C. Georgia,	Cornell University, B.Sc., 1913.
Assistant in physical education,	Harold M. Gore,	Massachusetts Agricultural College, B.Sc., 1913.
Assistant in mathematics,	Burt A. Hazeltine,	Tufts College, B.Sc., 1913.
Graduate assistant in landscape gardening,	Walter H. Hillary,	Pennsylvania State College, B.Sc., 1913.
Graduate assistant in microbiology,	Arao Itano,	Michigan Agricultural College, B.Sc., 1911.
Graduate assistant in agronomy,	Russell F. Lund,	St. Lawrence University, B.A., 1909.
Assistant professor of physics,	Harold E. Robbins,	Trinity College, B.Sc., 1908; Yale University, M.A., 1911.
Graduate assistant in chemistry,	Harold A. Robinson,	New Hampshire College, B.Sc., 1913.
Graduate assistant in chemistry,	Paul Serex, Jr.,	Massachusetts Agricultural College, B.Sc., 1913.
Graduate assistant in rural sociology,	Carl J. Strand,	Augustana College, A.B., 1907; University of Illinois, A.M., 1908.
Graduate assistant in floriculture,	Clark L. Thayer,	Massachusetts Agricultural College, B.Sc., 1913.
Assistant professor of microbiology,	Frans Herman Hesselink Van Suchtelen.	University of Göttingen, Ph.D., 1910.

In the Experiment Station.

Position.	Name.	Institution from which graduated and Degrees.
Assistant chemist,	James P. Buckeley, Jr.	Massachusetts Institute of Technology.[1]
Assistant chemist,	Walter S. Frost,	Tufts College, B.Sc., 1912.
Research biologist,	Hubert D. Goodale,	Trinity College, A.B., 1903; Trinity College, A.M., 1904; Columbia University, Ph.D.,1907.
Graduate assistant in horticulture,	John B. Norton,	University of Vermont, B.Sc., 1913.

In the Extension Service.

Extension professor of home economics,	Miss Laura Comstock,	Buffalo State Normal 1895; Pratt Institute, 1909.
Instructor in civic improvement,	Philip H. Elwood, Jr.,	Michigan Agricultural College, B.Sc., 1905; Cornell University, B.S.A., 1910.
Supervisor of correspondence courses,	Erwin H. Forbush,	Connecticut Agricultural College, 1910.
Demonstrator in charge of automobile truck.	Allister F. McDougall,	Massachusetts Agricultural College, B.Sc., 1913.

[1] Did not graduate.

In the Clerical Force.

Position.	Name.
Clerk in the library,	Miss Clarissa C. Babcock.
Clerk in the library,	Miss Ada M. Chandler.
Library assistant,	Miss Lena Chapman.
Assistant to the dean,	Miss Bertha E. Christiansen.
Stenographer, extension service,	Miss Marion S. Donaldson.
Clerk in the division of humanities and in the experiment station,	Miss Rebecca L. Mellor.
Stenographer, extension service,	Miss Cora B. Grover.
Stenographer, department of entomology,	Miss Marion Guertin.
Clerk to the director of the graduate school and in the division of agriculture.	Miss Esther L. Houghton.
Clerk, department of poultry husbandry,	Miss Fay L. Milton.
Stenographer, division of rural social science,	Miss Nell C. Milton.
Stenographer, extension service,	Miss Ina M. Paige.
Clerk, department of floriculture,	Miss Dorothy Smith.
Clerk, registrar's office,	Miss Olive M. Turner.

Miscellaneous.

Position.	Name.
Farm superintendent,	John J. Barber.
Foreman of apiary,	John L. Byard.
Foreman of grounds,	Lawrence S. Dickinson.

Resignations.

Instructor in physics,	Chester A. Butman.
Supervisor of correspondence courses,	Arthur T. Dailey.
Farm superintendent,	Edwin H. Forristall.
Clerk, department of floriculture,	Miss Helen V. Gaskill.
Stenographer, department of rural social science,	Miss Ruth M. Hager.
Lecturer in history,	George N. Holcomb.
Clerk, registrar's office,	Miss Georgia A. King.
Clerk, department of poultry husbandry,	Miss Mary R. Kingsbury.
Clerk, dean's office,	Miss Virginia Noble.
Assistant in mathematics and military science,	Samuel R. Parsons.
Assistant chemist, experiment station,	George R. Pierce.
Assistant chemist, experiment station,	James C. Reed.
Correspondence clerk, president's office,	Miss Stella H. Webb.
Professor of floriculture,	Edward A. White.
Assistant professor of market gardening,	Frederick L. Yeaw.

Change in Title of Officers of the Institution.

Name.	Former Title.	Present Title.
Joseph S. Chamberlain,	Associate professor of organic and agricultural chemistry.	Professor of organic and agricultural chemistry.
Walter W. Chenoweth,	Instructor in pomology,	Assistant professor of pomology.
George E. Gage,	Assistant professor of veterinary science.	Associate professor of veterinary science.
John C. Graham,	Associate professor of poultry husbandry.	Professor of poultry husbandry.
Arthur K. Harrison,	Instructor in landscape gardening.	Assistant professor of landscape gardening.
William P. B. Lockwood,	Associate professor of dairying,	Professor of dairying.
Elmer M. McDonald,	Instructor in agronomy,	Assistant professor of agronomy.
Jacob K. Shaw,	Assistant horticulturist, experiment station.	Research pomologist of the experiment station.

Report of the Treasurer.

For the Fiscal Year ending Nov. 30, 1913.

Balance Sheet.

		Dr.	Cr.
1912. Dec. 1.	To balance on hand,	$23,270 91	
1913. Nov. 30.	To receipts for fiscal year (see Schedule A),	557,930 17	
	Expenditures for fiscal year (see Schedule B),		$540,217 78
	Balance on hand,		40,983 30
		$581,201 08	$581,201 08

Statement of the First National Bank of Amherst with the Massachusetts Agricultural College.

		Dr.	Cr.
1912. Dec. 1.	Balance on hand,	$45,209 67[1]	
1913. Nov. 30.	Deposits for year,	559,479 51	
	Interest,	1,748 91	
	Disbursements as per warrants,		$545,433 72
	Balance on hand,		61,004 37[1]
		$606,438 09	$606,438 09

[1] These amounts are greater Dec. 1, 1912, by $28,791.20, and Nov. 30, 1913, $29,841.81, on account of outstanding checks.

Schedule A. — Income.

	Items.	Totals.
Income from students and others,		$104,090 89
Tuition fees,	$1,940 00	
Laboratory fees,	4,966 00	
Rents,	4,885 43	
Dining hall,	51,866 36	
Department sales,	34,556 42	
Department transfers,	2,829 92	
Miscellaneous,	3,046 76	

SCHEDULE A. — INCOME — *Concluded.*

		Items.	Totals.
Income from grants by nation and State: —			
State aid,			$315,216 58
Income from endowment,		$3,313 32	
Appropriation for current expenses,		185,000 00	
Administration,	$30,000 00		
Maintenance,	80,000 00		
Instruction,	75,000 00		
Appropriation for extension service,		$50,000 00	
Appropriation for experiment station,		21,000 00	
Maintenance,	$15,000 00		
Feed law,	6,000 00		
Receipts from special appropriations,		55,903 26	
Federal aid,			70,633 33
Income from land grant of 1862,		$7,300 00	
Income from Hatch fund of 1887,		15,000 00	
Income from Adams fund of 1906,		15,000 00	
Income from Nelson fund of 1907,		16,666 36	
Income from Morrill fund of 1890,		16,666 67	
Income from other sources: —			
Income from experiment station,			28,825 16
Fertilizer receipts,		$10,580 00	
Agricultural receipts,		2,746 36	
Cranberry receipts,		5,884 50	
Chemical receipts,		9,128 76	
Miscellaneous,		485 54	
Income from extension service,			5,971 21
Winter school receipts,		$3,489 15	
Summer school receipts,		902 99	
Correspondence courses receipts,		693 70	
Itinerant instruction receipts,		530 91	
Miscellaneous,		354 46	
Received on account of student trust funds,			33,193 00
			$557,930 17

Classification of Income from Students and Others.

	Laboratory Fees.	Department Sales.	Transfers.	Rents.	Income.	Miscellaneous.	Dining Hall.	Tuition.	Total.
Agricultural education,	–	$22 74	$228 25	–	–	–	–	–	$250 99
Agronomy,	$100 25	8 83	–	–	–	–	–	–	109 08
Animal husbandry,	–	–	30	–	–	–	–	–	30
Botany,	712 45	22 45	–	–	–	–	–	–	734 90
Chemistry,	2,732 75	19 52	32 48	–	–	–	–	–	2,784 75
North dormitory,	–	–	–	$2,308 34	–	–	–	–	2,308 34
South dormitory,	–	–	–	2,127 67	–	–	–	–	2,127 67
Chapel,	–	–	2 13	–	–	–	–	–	2 13
College residences,	–	–	–	449 42	–	–	–	–	449 42
Dairying,	–	3,994 16	555 24	–	–	–	–	–	4,549 40
Entomology,	176 50	15 47	–	–	–	–	–	–	191 97
Farm,	–	19,861 99	996 82	–	–	–	–	–	20,858 81
Farm administration,	–	33 85	–	–	–	–	–	–	33 85
Floriculture,	–	3,295 64	25 00	–	–	–	–	–	3,320 64
General horticulture,	–	1,123 93	301 74	–	–	–	–	–	1,425 67
Grounds,	–	85	2 23	–	–	–	–	–	3 08
Landscape gardening,	487 50	–	1 60	–	–	–	–	–	489 10
Library,	–	139 07	5 50	–	$416 68	–	–	–	561 25
Market gardening,	–	2,103 69	27 43	–	–	–	–	–	2,131 12
Microbiology,	210 00	–	–	–	–	–	–	–	210 00
Military,	–	5 50	–	–	–	–	–	–	5 50
Physical education,	140 00	2 50	–	–	–	–	–	–	142 50
Physics,	–	–	2 30	–	–	–	–	–	2 30
Pomology,	67 55	1,780 77	7 50	–	–	–	–	–	1,855 82
Poultry,	15 00	2,070 04	74 14	–	–	–	–	–	2,159 18
Veterinary,	–	5 00	16 65	–	–	–	–	–	21 65
Zoölogy,	324 00	8 45	65	–	–	–	–	–	333 10
Operating and maintenance,	–	–	299 96	–	–	$2,630 08	–	$1,940 00	4,870 04
Treasurer's office,	–	11 27	–	–	–	–	–	–	11 27
President's office,	–	4 20	–	–	–	–	–	–	4 20
Salaries,	–	–	250 00	–	–	–	–	–	250 00
Hospital,	–	26 50	–	–	–	–	–	–	26 50
Dining hall,	–	–	–	–	–	–	$51,866 36	–	51,866 36
	$4,966 00	$34,556 42	$2,829 92	$4,885 43	$416 68	$2,630 08	$51,866 36	$1,940 00	$104,090 89

Schedule B. — Expenditures for Fiscal Year.

	Items.	Totals.
College expense,		$284,080 75
Administration,	$29,404 08	
Maintenance,	140,815 22	
Instruction,	109,482 25	
Hospital expense,	4,379 20	
Experiment station,		75,757 55
Administration,	$1,234 06	
Feed inspection,	6,184 05	
Fertilizer law,	10,560 77	
Salaries,	32,679 14	
Departments,	25,099 53	
Extension service,		46,297 65
Special appropriations,		51,548 35
Student trust funds,		31,633 42
Dining hall,		50,900 06
		$540,217 78

Analysis of College Expenditures.

Administration.	Office Expense.	Salaries and Labor.	Travel.	Minor Equipment.	Building Supplies.	Publicity and Lectures.	Student Activity.	Commencement.	Miscellaneous.	Total.
Dean's office,	$199 49	$229 51	$1 14	$61 70	–	–	–	–	–	$491 84
Executive order,	–	–	1,811 62	–	–	$1,471 40	$1,059 07	$444 61	$1,511 12	6,297 82
President's office,	724 71	106 81	100 37	–	$3 10	–	–	–	–	934 99
Registrar's office,	315 23	47 87	30 05	7 54	46	–	–	–	–	401 15
Treasurer's office,	486 29	353 23	155 09	20 70	40 72	–	–	–	62 50	1,118 53
Administration (salaries),	–	20,159 75	–	–	–	–	–	–	–	20,159 75
Totals,	$1,725 72	$20,897 17	$2,098 27	$89 94	$44 28	$1,471 40	$1,059 07	$444 61	$1,573 62	$29,404 08

Maintenance.	Office Expense.	Labor.	Laboratory Supplies.	Refunds.	Minor Equipment.	Building Supplies.	Travel.	General Expense.	Salaries.	Totals.
Academic maintenance: —										
Agricultural economics,	$50 91	$94 33	$4 78	–	$22 75	–	$10 05	–	–	$182 82
Agricultural education,	250 04	33 51	104 18	$228 25	8 25	–	54 71	–	–	678 94
Agronomy,	55 56	143 52	151 61	3 00	6 69	$1 98	43 50	–	–	405 86
Animal husbandry,	59 42	102 55	54 68	–	24 44	5 39	68 62	–	–	315 10
Botany,	172 30	828 82	417 73	53 00	83 32	69 20	19 62	–	–	1,643 99
Chemistry,	132 49	750 52	2,639 68	654 27	93 19	130 05	20 70	–	–	4,420 90
Dairying,	127 48	513 24	5,623 61	–	181 07	104 54	61 41	–	–	6,611 35
Economics and sociology,	10 21	27 25	29 10	–	3 12	9 68	–	–	–	79 36
Entomology,	104 19	900 49	272 04	6 00	139 83	123 91	26 63	–	–	1,573 09
Farm administration,	153 11	49 76	53 39	–	67 38	–	42 65	–	–	366 29
Floriculture,	83 51	2,784 29	865 58	27 43	128 64	97 51	60 04	–	–	4,047 00
Forestry,	56 55	2 80	21 00	–	77 89	–	63 57	–	–	221 81
History and government,	21 99	10 63	1 92	–	–	–	3 00	–	–	37 54
Landscape gardening,	16 65	29 34	311 58	10 50	7 96	1 95	9 05	–	–	387 03
Language and literature,	51 22	58 24	97 43	–	91 96	1 84	–	–	–	300 69

Market gardening,	17 28	2,642 53	843 07	–	22 46	24 10	83 79	–	–	3,633 23
Mathematics,	30 47	82 00	32 38	–	2 28	14 35	–	–	–	161 48
Microbiology,	122 12	80 54	173 90	35 00	20 20	17 55	–	–	–	449 31
Military,	451 72	852 73	23 75	–	258 79	54 20	6 00	–	–	1,647 19
Physical education,	87 58	175 52	116 31	–	58 39	59 73	257 35	–	–	754 88
Physics,	13 04	200 53	138 70	–	33 90	17 26	–	–	–	403 43
Pomology,	90 82	2,278 52	1,115 24	–	85 74	24 34	44 30	–	–	3,638 96
Poultry husbandry,	203 49	1,153 68	2,552 02	1 50	106 10	40 94	46 49	–	–	4,104 22
Rural sociology,	9 13	–	10 03	–	–	–	8 70	–	–	27 86
Veterinary science,	41 89	357 01	766 97	–	610 33	125 96	15 34	–	–	1,917 50
Zoölogy and geology,	17 63	236 49	200 85	8 00	107 57	4 80	5 75	–	–	581 09
General maintenance: —										
Equipment,	–	–	–	–	–	–	–	$15,421 90	–	15,421 90
Farm,	–	–	–	–	–	–	–	24,830 70	–	24,830 70
General horticulture,	–	–	–	–	–	–	–	3,735 20	–	3,735 20
Graduate school,	–	–	–	–	–	–	–	33 25	–	33 25
Grounds,	–	–	–	–	–	–	–	2,937 01	–	2,937 01
Library,	–	–	–	–	–	–	–	6,523 60	–	6,523 60
Operating and maintenance,	–	–	–	–	–	–	–	48,742 64	–	48,742 64
	$2,430 80	$14,388 84	$16,621 53	$1,026 95	$2,242 25	$929 28	$951 27	$102,224 30	–	$140,815 22
Instruction: —										
Salaries,	–	–	–	–	–	–	–	–	$109,482 25	109,482 25
	–	–	–	–	–	–	–	–	$109,482 25	$250,297 47
Hospital: —										
Emergency expense,	–	–	–	–	–	–	–	$4,379 20	–	4,379 20
Grand total,	–	–	–	–	–	–	–	–	–	$284,080 75

Current Accounts.

Disbursements and Receipts.

Accounts.	Disbursements from Dec. 1, 1912, to Nov. 30, 1913.	Receipts from Dec. 1, 1912, to Nov. 30, 1913.	Apportionment for Year ending Nov. 30, 1913.	Balance to Credit.
Administration: —				
Dean's office,	$491 84	–	$400 00	—$91 84
Executive order,	6,297 82	–	6,200 00	—97 82
President's office,	934 99	$4 20	1,000 00	69 21
Registrar's office,	401 15	–	400 00	—1 15
Salaries,	20,159 75	–	20,900 00	740 25
Treasurer's office,	1,118 53	11 27	1,100 00	—7 26
State Treasurer,	–	30,000 00	–	–
Maintenance: —				
Agricultural economics,	182 82	–	150 00	—32 82
Agricultural education,	678 94	250 99	300 00	—127 95
Agronomy,	405 86	109 08	200 00	—96 78
Animal husbandry,	315 10	30	275 00	—39 80
Botany,	1,643 99	734 90	500 00	—409 09
Chemistry,	4,420 90	2,784 75	1,800 00	163 85
Dairying,	6,611 35	4,549 40	2,300 00	238 05
Economics and sociology,	79 36	–	50 00	—29 36
Entomology,	1,573 09	191 97	1,225 00	—156 12
Farm administration,	366 29	33 85	300 00	—32 44
Floriculture,	4,047 00	3,320 64	1,200 00	473 64
Forestry,	221 81	–	300 00	78 19
History and government,	37 54	–	50 00	12 46
Landscape gardening,	387 03	489 10	100 00	202 07
Language and literature,	300 69	–	650 00	349 31
Market gardening,	3,633 23	2,131 12	2,400 00	897 89
Mathematics,	161 48	–	225 00	63 52
Microbiology,	449 31	210 00	400 00	160 69
Military science,	1,647 19	5 50	1,500 00	—141 69
Physical education,	754 88	142 50	550 00	—62 58
Physics,	403 43	2 30	350 00	—51 13
Pomology,	3,638 96	1,855 82	1,900 00	116 86
Poultry husbandry,	4,104 22	2,159 18	1,800 00	—145 04
Rural sociology,	27 86	–	50 00	22 14
Veterinary science,	1,917 50	21 65	750 00	—1,145 85
Zoölogy and geology,	581 09	333 10	250 00	01
Hospital account,	4,379 20	26 50	–	—4,352 70
Maintenance, general: —				
Equipment,	15,421 90	–	15,000 00	—421 90
Farm,	24,830 70	20,858 81	5,500 00	1,528 11
General horticulture,	3,735 20	1,425 67	2,300 00	—9 53
Graduate school,	33 25	–	100 00	66 75
Grounds,	2,937 01	3 08	3,250 00	316 07
Library,	6,523 60	561 25	5,800 00	—162 35
Operating and maintenance,	48,742 64	9,757 60	44,000 00	—4,742 64
State Treasurer, maintenance,	–	80,000 00	–	–
Endowment fund,	–	10,613 32	–	–
Instruction: —				
Salaries,	109,482 25	250 00	–	–
United States Treasurer: —				
Morrill fund,	–	16,666 66	–	–
Nelson fund,	–	16,666 67	–	–
State Treasurer: —				
Instruction,	–	75,000 00	–	–
	$284,080 75	$281,171 18	–	–
Balance beginning fiscal year Dec. 1, 1912,	–	19,288 62	–	–
Balance on hand Nov. 30, 1913,	16,379 05	–	–	–
	$300,459 80	$300,459 80	–	–

College Accounts.

Comparative Disbursements and Receipts for 1912-13.

Accounts.	Disbursements.		Receipts.	
	1912.	1913.	1912.	1913.
Administration,	$6,177 60	–	$24 72	–
Agricultural economics,	102 11	$182 82	–	–
Agricultural education,	1,266 84	678 94	122 62	$250 99
Agronomy,	206 40	405 86	5 20	109 08
Agricultural division,	26,207 33	–	19,919 02	–
Animal husbandry,	264 01	315 10	3 89	30
Botany,	1,558 75	1,643 99	970 63	734 90
Chemistry,	3,958 87	4,420 90	2,648 23	2,784 75
Dairying,	205 80	6,611 35	20	4,549 40
Dean's office,	353 02	491 84	11 00	–
Economics and sociology,	48 35	79 36	–	–
Entomology,	1,359 83	1,573 09	263 99	191 97
Equipment,	–	15,421 90	–	–
Executive order,	–	6,297 82	–	–
Farm administration,	212 66	366 29	11 38	33 85
Farm,	–	24,830 70	–	20,858 81
Floriculture,	3,887 99	4,047 00	2,869 75	3,320 64
Forestry,	184 57	221 81	–	–
General agriculture,	537 28	–	51 63	–
General horticulture,	2,791 01	3,735 20	599 54	1,425 67
General maintenance,	63,093 90	–	22,094 07	–
Graduate school,	1 50	33 25	–	–
Grounds,	3,114 11	2,937 01	85	3 08
History and government,	19 93	37 54	–	–
Hospital,	–	4,379 20	–	26 56
Landscape gardening,	444 55	387 03	473 03	489 10
Language and literature,	544 37	300 69	–	–
Library,	6,591 12	6,523 60	590 40	561 25
Market gardening,	4,452 21	3,633 23	1,851 94	2,131 12
Mathematics,	209 81	161 48	–	–
Military,	1,547 43	1,647 19	–	5 50
Microbiology,	–	449 31	–	210 00
Physical education,	570 99	754 88	121 50	142 50
Physics,	227 94	403 43	–	2 30
Pomology,	3,502 47	3,638 96	1,233 52	1,855 82
Poultry husbandry,	3,214 79	4,104 22	1,235 41	2,159 18
President's office,	659 08	934 99	2 18	4 20
Registrar's office,	383 00	401 15	60	–
Rural sociology,	39 69	27 86	–	–
Salaries,	113,525 51	129,642 00	–	250 00
Treasurer's office,	891 20	1,118 53	6 88	11 27
Veterinary,	1,464 03	1,917 50	19 35	21 65
Zoölogy and geology,	571 58	581 09	329 69	333 10
Operating and maintenance,	–	48,742 64	–	9,757 60
State treasurer: —				
Endowment fund,	–	–	10,613 32	10,613 32
Maintenance,	–	–	58,000 00	80,000 00
Scholarship,	–	–	25,000 00	–
Instruction,	–	–	60,000 00	75,000 00
Administration,	–	–	–	30,000 00
United States Treasurer: —				
Morrill fund,	–	–	16,666 66	16,666 66
Nelson fund,	–	–	16,666 67	16,666 67
	$254,391 63	$284,080 75	$242,407 87	$281,171 18
Balance beginning fiscal year,	–	–	31,272 38	19,288 62
Balance on hand at close of fiscal year,	19,288 62	16,379 05	–	–
	$273,680 25	$300,459 80	$273,680 25	$300,459 80

Summary.

	Disbursements.	Receipts.
Cash on hand Dec. 1, 1912,	–	$19,288 62
Institution receipts Nov. 30, 1913,	–	52,224 53
State Treasurer's receipts Nov. 30, 1913,	–	195,613 32
United States Treasurer's receipts Nov. 30, 1913,	–	33,333 33
Total disbursements,	$284,080 75	–
	$284,080 75	$300,459 80
Bills receivable Dec. 1, 1912, deducted,	–	4,058 51
Bills payable Dec. 1, 1912, deducted,	2,964 94	–
	$281,115 81	$296,401 29
Bills receivable Nov. 30, 1913,	–	3,827 63
Bills payable Nov. 30, 1913,	2,496 39	–
Balance,	16,616 72	–
	$300,228 92	$300,228 92

College Equipment, 1913.

	Disbursements Fiscal Year.		Disbursements Fiscal Year.
Forestry,	$118 10	Agronomy,	$95 38
Farm,	479 27	Farm administration,	94 34
Dairy,	4,332 92	Floriculture,	186 36
Draper hall,	1,151 41	Landscape gardening,	145 02
Animal husbandry,	2,642 97	Pomology,	99 19
Poultry,	451 88	Botany,	29 70
Mathematics,	277 20	Chemistry,	200 00
Physical education,	168 67	Apiary,	57 30
Rural social science,	38 75	Physics,	144 56
Veterinary,	125 50	Zoölogy,	100 00
Entomology,	410 76	Microbiology,	3,216 42
Operating and maintenance,	189 92	Agricultural education,	26 00
Registrar's office,	482 25		$15,421 90
Dean's office,	158 03		

FARM DISBURSEMENTS.

	Labor.	Equipment.	Feed.	Fertilizers.	Seeds.	Miscellaneous.	Supplies.	Improvements.	Totals.
Dairy,	$1,066 43	$197 39	–	–	–	–	$1,538 07	–	$2,801 89
Cattle,	3,592 87	–	$4,859 85	–	–	$1,667 11	–	–	10,119 83
Horses,	1,434 42	–	721 51	–	–	–	478 48	–	2,634 41
Swine,	395 68	–	431 53	–	–	252 06	–	–	1,079 27
Sheep,	113 63	–	4 60	–	–	–	10 67	–	128 90
Field crops,	2,208 48	–	–	$1,139 12	$263 16	101 33	–	–	3,712 09
Tools and machinery,	–	–	–	–	–	633 48	–	–	633 48
Miscellaneous,	2,909 34	–	–	–	–	36 79	–	$774 70	3,720 83
	$11,720 85	$197 39	$6,017 49	$1,139 12	$263 16	$2,690 77	$2,027 22	$774 70	$24,830 70

FARM CREDITS.

	Milk.	Stock.	Sundry.	Corn.	Hay.	Potatoes.	Roots.	Wool.	Labor.	Totals.
Dairy,	$4,854 50	–	$11 20	–	–	–	–	–	–	$4,865 70
Swine,	–	$873 01	1 00	–	–	–	–	–	–	874 01
Cattle,	10,219 20	1,748 76	451 48	–	–	–	–	–	–	12,419 44
Horses,	–	306 50	727 05	–	–	–	–	–	–	1,033 55
Field crops,	–	–	–	$3 00	$114 48	$546 71	$50 63	–	–	714 82
Miscellaneous,	–	–	136 18	–	–	–	–	–	$798 01	934 19
Sheep,	–	–	–	–	–	–	–	$17 10	–	17 10
	$15,073 70	$2,928 27	$1,326 91	$3 00	$114 48	$546 71	$50 63	$17 10	$798 01	$20,858 81

Agricultural Division.

Disbursements and Receipts.

	Disbursements.	Receipts.
Agronomy,	$405 86	$109 08
Animal husbandry,	315 10	30
Dairying,	6,611 35	4,549 40
Farm,	24,830 70	20,858 81
Farm administration,	366 29	33 85
Poultry husbandry,	4,104 22	2,159 18
Division totals,	$36,633 52	$27,710 62

Summary.

	Dr.	Cr.
By total division receipts,		$27,710 62
By bills receivable,		3,136 52
By net apportionment,		10,375 00
To total disbursements,	$36,633 52	
To bills payable,	183 10	
To balance,	4,405 52	
	$41,222 14	$41,222 14

Inventory of Quick Assets.

	Nov. 30, 1912.	Nov. 30, 1913.
Inventory of produce,	$7,010 93	$6,431 98
Inventory of cattle,	11,148 00	11,935 00
Inventory of swine,	731 00	286 00
Inventory of horses,	4,090 00	5,150 00
Inventory of poultry,	1,524 15	1,598 70
Inventory of sheep,	200 00	443 00
	$24,704 08	$25,844 68

Horticultural Division.

Disbursements and Receipts.

	Disbursements.	Receipts.
Floriculture,	$4,047 00	$3,320 64
Forestry,	221 81	–
General horticulture,	3,735 20	1,425 67
Grounds,	2,937 01	3 08
Landscape gardening,	387 03	489 10
Market gardening,	3,633 23	2,131 12
Pomology,	3,638 96	1,855 82
	$18,600 24	$9,225 43

Summary.

	Dr.	Cr.
By total division receipts,		$9,225 43
By bills receivable,		381 17
By apportionment,		11,450 00
To total division disbursements,	$18,600 24	
To bills payable,	20 30	
To balance,	2,436 06	
	$21,056 60	$21,056 60

Inventory of Quick Assets.

	Nov. 30, 1912.	Nov. 30, 1913.
Inventory of supplies,	$621 25	$713 25

Expense Operating and Maintenance.

	Salaries.	Labor.	Fuel and Water.	Repairs.	Supplies.	Tools.	Architect.	Engineer.	Miscellaneous.	Total.
General: —										
General superintendent,	$2,497 12	–	–	–	–	–	–	–	–	$2,497 12
Office,	–	$936 13	–	–	–	–	–	–	–	936 13
General expenses,	–	–	–	–	$1,885 14	–	–	–	–	1,885 14
Power plant: —										
Heating,	–	4,063 70	$19,739 76	$773 94	102 56	–	–	–	–	24,679 96
Lighting,	–	131 08	–	446 91	34 09	–	–	–	$32 55	644 63
Tools,	–	–	–	–	–	$474 49	–	–	–	474 49
Expert services,	–	–	–	–	–	–	$1,709 85	$57 61	–	1,767 46
Emergency maintenance,	–	–	–	–	–	–	–	–	1,501 69	1,501 69
Fire department,	903 00	75 20	–	–	42 77	–	–	–	–	1,020 97
Roads,	–	304 82	–	–	–	–	–	–	–	304 82
Night watch,	–	1,224 48	–	–	–	–	–	–	–	1,224 48
Mail service,	–	277 73	–	–	–	–	–	–	–	277 73
Waiting station janitor,	–	13 46	–	–	–	–	–	–	–	13 46
Water mains,	–	91 94	–	–	–	–	–	–	–	91 94
Steam mains,	–	327 88	–	–	–	–	–	–	–	327 88
Electric light circuit,	–	322 28	–	–	–	–	–	–	–	322 28
Sewers and cesspools,	–	20 04	–	–	–	–	–	–	–	20 04
Sundry,	–	–	–	–	–	–	–	–	1,801 87	1,801 87
Amherst Water Company,	–	–	2,061 77	–	–	–	–	–	–	2,061 77
Totals,	$3,400 12	$7,788 74	$21,801 53	$1,220 85	$2,064 56	$474 49	$1,709 85	$57 61	$3,336 11	$41,853 86

Operating and Maintenance Expense — Continued.

College Buildings.	Electric Repairs.	Plumbing Repairs.	Heat Repairs.	C. and M. Repairs.	Janitors.	Bell Ringing.	Sundry.	Totals.
Animal husbandry,	-	$0 63	$0 28	$7 47	-	-	-	$8 38
Horse barn,	-	6 97	34 93	16	-	-	-	42 06
Dairy barn,	$2 00	38 96	244 06	19 69	-	-	-	304 71
Young stock barn,	-	25 38	50	3 06	-	-	-	28 94
Power building,	12 53	29 76	5 87	632 95	$90 86	-	-	771 97
Chemical building,	25 15	26 59	16 38	10 63	-	-	-	78 75
Poultry buildings,	6 07	3 14	2 32	4 98	-	-	-	16 51
Dairy building,	1 69	75 66	134 84	81 20	-	-	-	293 39
Drill hall,	8 40	9 96	53 78	9 81	-	-	-	81 95
Veterinary,	2 51	10 23	-	96 89	-	-	-	109 63
Apiary,	75	5 16	9 88	35 14	-	-	-	50 93
Mathematical building,	1 56	6 50	3 00	99 37	-	-	-	110 43
Entomology building,	13 04	53 23	19 39	77 85	-	-	-	163 51
Clark Hall,	17 15	36 63	-	1 78	-	-	-	55 56
French Hall,	34 93	1 08	10 43	15 94	-	-	-	62 38
Wilder Hall,	5 14	11 41	3 47	33 96	-	-	-	53 98
Upper plant house,	-	-	3 98	-	-	-	-	3 98
Old Durfee range,	1 25	25	1 82	-	-	-	-	3 32
Horticultural barns,	-	-	18	44 79	-	-	-	44 97
Physics building,	-	10 68	4 05	75 02	-	-	-	89 75
East experiment station,	-	4 71	32 27	11 14	-	-	-	48 12
West experiment station,	6 47	4 16	32 69	4 29	-	-	-	47 61
Experiment station barn,	-	34	99	64 46	-	-	-	65 79
P. and A. Chem. barn,	1 61	12 18	8 42	5 50	-	-	-	27 71
Pomology building,	46	-	-	1 62	-	-	-	2 08
Kellogg barn,	-	-	-	270 98	-	-	-	270 98
North College,	83 04	10 30	6 90	126 38	405 96	-	$58 00	690 58
South College,	99 04	220 57	57 36	1,407 16	410 55	-	15 00	2,209 68
Chapel,	17 79	27 20	3 83	52 96	225 46	$110 00	-	437 24
	$340 58	$631 68	$691 62	$3,195 18	$1,132 83	$110 00	$73 00	$6,174 89

Operating and Maintenance Expense — Concluded.

College Buildings.	Electric Repairs.	Plumbing Repairs.	Heat Repairs.	C. and M. Repairs.	Janitors.	Bell Ringing.	Sundry.	Totals.
College residences: —								
President's house,	$10 33	$24 75	$12 55	$31 53	–	–	$50 45	$129 61
Registrar's house,	–	58	1 31	–	–	–	–	1 89
House for head of horticultural division,	46	–	3 19	77 38	–	–	–	81 03
Farm superintendent's house,	6 52	47 65	21 86	15 59	–	–	–	91 62
Farm help's house,	–	–	–	26 52	–	–	–	26 52
Stockbridge house,	–	25	–	67	–	–	–	92
Experiment station superintendent's house,	–	–	–	1 65	–	–	–	1 65
Harlow house,	–	–	–	128 20	–	–	–	128 20
Kellogg House,	–	–	–	252 45	–	–	–	252 45
	$17 31	$73 23	$38 91	$533 99	–	–	$50 45	$713 89

Summary.

General,	$41,853 86
College buildings,	6,174 89
College residences,	713 89
	$48,742 64

Experiment Station.

Disbursements and Receipts.

Accounts.	Disbursements from Dec. 1, 1912, to Nov. 30, 1913.	Receipts from Dec. 1, 1912, to Nov. 30, 1913.	Apportionment for Year ending Nov. 30, 1913.	Balance to Credit.
Administration,	$860 79	$4 54	$1,600 00	$743 75
Agricultural,	4,841 79	2,746 36	2,000 00	—95 43
Asparagus,	483 27	–	700 00	216 73
Botanical,	1,672 90	–	1,350 00	—322 90
Chemical,	9,362 54	9,128 76	400 00	166 22
Cranberry,	3,135 53	5,884 50	2,000 00	4,748 97
Entomological,	425 96	3 20	650 00	227 24
Fertilizer,	10,560 77	10,580 00	10,000 00	1,486 62
Freight,	248 24	56	300 00	52 32
Feed law,	6,184 05	6,000 00	6,000 00	897 40
Graves orchard,	466 93	399 04	400 00	332 11
Horticultural,	1,492 20	78 20	1,300 00	—114 00
Library,	64 00	–	75 00	11 00
Meteorology,	299 27	–	375 00	75 73
Poultry,	910 51	–	908 00	—2 51
Publications,	978 37	–	1,150 00	171 63
Salaries,	32,679 14	–	33,090 00	410 86
Treasurer's office,	373 27	–	300 00	—73 27
Veterinary,	718 02	–	725 00	6 98
Hatch fund,	–	15,000 00	–	–
Adams fund,	–	15,000 00	–	–
State fund,	–	15,000 00	–	–
	$75,757 55	$79,825 16	$63,323 00	$9,547 56 —608 11
Balance on hand beginning fiscal year Dec. 1, 1912,	–	3,084 29	–	–
Balance on hand Nov. 30, 1913,	7,151 90	–	–	–
	$82,909 45	$82,909 45	$63,323 00	$8,939 45

Comparative Disbursements and Receipts 1912-13.

Accounts.	Disbursements.		Receipts.	
	1912.	1913.	1912.	1913.
Administration,	$1,690 19	$860 79	$2 94	$4 54
Agriculture,	4,469 62	4,841 79	1,920 80	2,746 36
Asparagus,	733 84	483 27	–	–
Botanical,	1,127 23	1,672 90	6 17	–
Chemical,	9,397 06	9,362 54	8,980 25	9,128 76
Cranberry,	3,228 96	3,135 53	2,337 89	5,884 50
Entomology,	466 03	425 96	–	3 20
Fertilizer,	8,533 60	10,560 77	10,000 99	10,580 00
Freight,	275 76	248 24	80	56
Feed law,	4,345 00	6,184 05	3,750 00	6,000 00
Graves orchard,	676 33	466 93	30 00	399 04
Horticulture,	1,539 15	1,492 20	50	78 20
Library,	89 48	64 00	–	–
Meteorology,	397 05	299 27	–	–
Poultry,	247 55	910 51	–	–
Publications,	1,263 53	978 37	–	–
Salaries,	29,640 69	32,679 14	–	–
Treasurer's office,	253 18	373 27	–	–
Veterinary,	275 16	718 02	113 00	–
Hatch fund,	–	–	15,000 00	15,000 00
Adams fund,	–	–	15,000 00	15,000 00
State fund,	–	–	10,500 00	15,000 00
	$68,649 41	$75,757 55	$67,643 34	$79,825 16
Balance beginning fiscal year,	–	–	4,090 36	3,084 29
Balance on hand at close of fiscal year,	3,084 29	7,151 90	–	–
	$71,733 70	$82,909 45	$71,733 70	$82,909 45

Inventory of Quick Assets, Agricultural Department of Experiment Station.

Produce on hand Nov. 30, 1913, ... $813 20

Analysis of Experiment Station Accounts.

	Adams Fund.	Feed Law.	Fertilizer Law.	Hatch Fund.	State Fund.	Totals.
Salaries,	$11,853 34	$4,133 69	$6,595 32	$10,437 44	$10,221 70	$43,241 49
Labor,	865 61	380 32	840 32	1,537 74	10,442 73	14,066 72
Publications,	–	–	842 25	798 78	182 00	1,823 03
Postage and stationery,	10 50	182 22	184 36	32 19	958 98	1,368 25
Freight and express,	13 01	–	52 90	75	283 93	350 59
Heat, light, water, power,	56 38	49 50	127 88	10 75	222 51	467 02
Chemical and laboratory supplies,	447 70	520 42	472 60	75 96	343 12	1,859 80
Seeds, plants and sundries,	144 65	26 58	41 41	239 84	1,089 61	1,542 09
Fertilizer,	74 02	–	39 40	657 02	296 41	1,066 85
Feeding stuffs,	–	–	–	87 30	1,919 48	2,006 78
Library,	14 08	11 43	39 66	48 05	219 01	332 23
Tools, machinery and appliances,	4 08	166 79	12 21	109 01	522 00	814 09
Furniture and fixtures,	29 04	14 00	133 66	14 25	736 93	927 88
Scientific apparatus and specimens,	152 36	145 22	208 13	79 52	316 96	902 19
Live stock,	–	–	–	7 40	253 60	261 00
Traveling expense,	89 65	415 97	738 60	–	1,550 19	2,794 41
Contingent expenses,	–	105 90	100 00	–	555 00	760 90
Buildings and land,	223 45	32 01	132 07	54 42	730 28	1,172 23
	$13,977 87	$6,184 05	$10,560 77	$14,190 42	$30,844 44	$75,757 55

Summary.

	Disbursements.	Receipts.
Cash on hand Dec. 1, 1912,	–	$3,084 29
Receipts from State Treasurer,	–	21,000 00
Receipts from United States Treasurer,	–	30,000 00
Receipts from other sources,	–	28,825 16
Total disbursements,	$75,757 55	–
	$75,757 55	$82,909 45
Bills receivable Nov. 30, 1913,	–	785 49
Bills payable Nov. 30, 1913,	20 52	–
Balance,	7,916 87	–
	$83,694 94	$83,694 94

Extension Service.

Disbursements and Receipts.

	Disbursements.	Receipts.	Apportionment.	Balance.
Administration,	$2,142 56	$93 56	$2,500 00	$451 00
Agricultural education,	2,012 00	14 25	2,300 00	302 25
Auto. Dem. outfit,	1,545 27	–	1,700 00	154 73
Civic improvement,	171 23	–	500 00	328 77
Community field agent,	626 67	–	700 00	73 33
Conference rural social work,	488 84	3 00	700 00	214 16
Correspondence courses,	1,084 77	693 70	500 00	108 93
Dairy improvement,	714 92	27 75	700 00	12 83
Demonstration orchards,	1,180 63	19 38	1,200 00	38 75
Director's office,	2,728 68	70 55	2,100 00	—558 13
District field agent,	108 78	–	200 00	91 22
Farm management,	923 28	11 70	920 00	8 42
Home economics,	113 62	–	450 00	336 38
Itinerant instruction,	2,462 83	530 91	2,000 00	68 08
Library,	203 59	–	200 00	—3 59
M. A. C. Improvement Association,	245 65	109 22	200 00	63 57
Summer school,	3,120 77	902 99	3,000 00	782 22

Disbursements and Receipts — Concluded.

	Disbursements.	Receipts.	Apportionment.	Balance.
Poultry husbandry,	$140 48	$5 05	$300 00	$164 57
Reserve and emergency,	-	-	6,865 00	6,865 00
Salaries,	20,389 05	-	20,165 00	—224 05
Winter school,	5,894 03	3,489 15	2,800 00	395 12
From State Treasurer,	-	50,000 00	-	-
	$46,297 65	$55,971 21	$50,000 00	$10,459 33
Balance Dec. 1, 1912, overdrawn,	-	—2,896 35	-	—785 77
Balance Nov. 30, 1913,	6,777 21	-	-	-
	$53,074 86	$53,074 86	$50,000 00	$9,673 56

Summary.

	Disbursements.	Receipts.
Overdraft Dec. 1, 1912,	$2,896 35	-
Receipts Nov. 30, 1913,	-	$5,971 21
Received from State Treasurer,	-	50,000 00
Disbursements Nov. 30, 1913,	46,297 65	-
	$49,194 00	$55,971 21
Bills receivable Dec. 1, 1912, deducted,	-	101 37
Bills payable Dec. 1, 1912, deducted,	916 95	-
	$48,277 05	$55,869 84
Bills receivable Nov. 30, 1913,	-	133 29
Bills payable Nov. 30, 1913,	505 96	-
Balance,	7,220 12	-
	$56,003 13	$56,003 13

Analysis of Extension Service Disbursements.

	Travel.	Equipment.	Laboratory Expense.	Printing.	Office Supplies.	Instruction and Lectures.	Salaries.	Miscellaneous.	Totals.
Administration,	$848 21	$253 29	–	$663 55	–	–	$20,389 05	$377 51	$22,531 61
Director's office,	7 63	1,217 93	–	–	$1,326 13	–	–	176 99	2,728 68
Demonstration orchards,	543 07	637 56	–	–	–	–	–	–	1,180 63
Correspondence courses,	34 29	–	–	–	1,047 48	–	–	3 00	1,084 77
Itinerant instruction,	15 38	–	–	–	–	$2,447 45	–	–	2,462 83
Dairy improvement,	526 49	188 43	–	–	–	–	–	–	714 92
Agricultural education,	569 89	1,256 85	–	–	93 04	–	–	92 22	2,012 00
Farm management,	681 45	241 83	–	–	–	–	–	–	923 28
Poultry husbandry,	117 73	22 75	–	–	–	–	–	–	140 48
Civic improvement,	43 02	128 21	–	–	–	–	–	–	171 23
M. A. C. Improvement Association,	–	–	–	–	245 65	–	–	–	245 65
Community field agent,	556 11	70 56	–	–	–	–	–	–	626 67
Winter course,	–	–	$3,736 77	26 75	–	624 56	–	–	4,388 08
Boys' and Girls' clubs,	–	–	–	–	–	–	–	2 50	2 50
Farmers' week,	–	–	–	–	–	944 26	–	–	944 26
Poultry,	–	–	–	–	–	–	–	128 06	128 06
Beekeepers' course,	–	–	–	–	–	233 17	–	–	233 17
Packing school,	–	–	–	–	–	–	–	135 00	135 00
Tree Warden's School,	–	–	–	–	–	62 96	–	–	62 96
Summer school,	–	–	438 05	273 95	–	2,352 41	–	56 36	3,120 77
Conference rural community leaders,	–	–	–	–	–	488 84	–	–	488 84
Library extension,	–	203 59	–	–	–	–	–	–	203 59
District field agent, Barnstable County,	–	108 78	–	–	–	–	–	–	108 78
Auto. Dem. outfit,	167 43	1,305 56	–	–	–	–	–	72 28	1,545 27
Home economics,	63 99	49 63	–	–	–	–	–	–	113 62
	$4,174 69	$5,684 97	$4,174 82	$964 25	$2,712 30	$7,153 65	$20,389 05	$1,043 92	$46,297 65

Special Appropriations.

Name of Appropriation.	Date made.	Amount of Appropriation.	Amount previously expended.	Amount expended during Fiscal Year.	Amount expended to Date.	Amount received from State Treasurer.	Balance on Hand with State Treasurer.
Addition to Draper Hall,	1912	$25,000 00	$18,314 53	$6,685 47	$25,000 00	$25,000 00	–
Architect's fees,	–	–	4,577 11	803 97	5,381 08	4,202 11	–
Dairy building,	1911	75,000 00	74,035 11	964 89	75,000 00	75,000 00	–
Farm buildings,	–	–	–	222 20	–	–	–
Special, 1912, miscellaneous,	1912	20,000 00	14,779 95	5,220 05	20,000 00	20,000 00	–
Special, 1912, repairs,	1912	15,000 00	8,128 84	6,871 16	15,000 00	15,000 00	–
Special, 1911, small buildings,	1911	15,000 00	14,774 35	225 65	15,000 00	15,000 00	–
Special, 1912, sewers,	1912	10,000 00	–	9,250 55	9,250 55	9,250 55	$749 45
Special, 1913, improvements and repairs,	1913	26,000 00	–	16,550 55	16,550 55	16,550 55	9,449 45
Special, 1913, addition to French Hall,	1913	35,000 00	–	4,753 86	4,753 86	4,753 86	30,246 14
		$221,000 00	$134,609 89	$51,548 35	$185,936 04	$184,757 07	$40,445 04

Inventory — Real Estate.

Land (Estimated Value).

Baker place,	$2,500 00
Bangs place,	2,350 00
Clark place,	4,500 00
College farm,	37,000 00
Cranberry land,	11,063 00
Harlow farm,	3,284 63
Kellogg farm,	5,686 45
Louisa Baker place,	5,636 91
Old creamery place,	1,000 00
Pelham quarry,	500 00
Westcott place,	2,250 00
Allen place,	500 00
Charmbury place,	450 00
Loomis place,	415 00
Hawley & Brown place,	675 00
Newell farm,	2,800 00
	$80,792 99

College Buildings (Estimated Value).

Apiary,	$3,000 00
Animal husbandry building,	10,000 00
Chemical laboratory,	8,000 00
Clark hall,	67,500 00
Cold-storage laboratory,	12,000 00
Dairy building,	75,000 00
Dairy barn and storage,	30,000 00
Dining hall,	60,000 00
Drill hall and gun shed,	10,000 00
Durfee range and glass houses, old,	10,000 00
Durfee range and glass houses, new,	15,000 00
Entomology building,	80,000 00
Farmhouse,	25,000 00
French hall,	17,000 00
Horse barn,	5,000 00
Horticultural barn,	2,500 00
Horticultural tool shed,	2,000 00
Machinery barn,	4,000 00
Mathematical building,	6,000 00
North dormitory,	25,000 00
Physics laboratory,	5,500 00
Poultry breeding house,	600 00
Poultry brooder house,	1,000 00
Poultry incubator cellar and demonstration building,	1,400 00
Poultry laboratory,	1,300 00
Poultry laying house,	1,800 00
Poultry mechanics and storage building,	1,900 00
Power plant and storage building,	18,500 00
President's house,	12,000 00
Quarantine barn,	200 00
Sheep shed,	1,400 00
Small plant house, with vegetable cellar and cold grapery,	4,700 00
South dormitory,	35,000 00

Stone chapel,		$30,000 00
Three houses on Stockbridge Road,		5,000 00
Veterinary laboratory and stable,		23,500 00
Waiting station,		500 00
Wilder hall,		37,500 00
Young stock barn,		6,500 00
		$632,800 00

College Equipment (Estimated Value).

Administrative division: —		
Dean's office,		$347 53
President's office,		876 70
Registrar's office,		877 10
Treasurer's office,		1,963 41
Agricultural division: —		
Agronomy,		1,541 23
Animal husbandry,		834 97
Dairy,		12,067 19
Farm administration,		1,271 05
Farm department,		30,081 37
Poultry,		4,221 80
Dining hall,		5,311 30
Extension department,		4,432 68
General science: —		
Apiary,		1,544 55
Botanical,		8,544 82
Chemical,		10,802 30
Entomology,		6,183 11
Microbiology,		5,107 71
Mathematics,		2,740 50
Physics,		3,536 94
Veterinary,		9,252 30
Zoölogical laboratory,		9,201 87
Zoölogical museum,		6,511 05
History and political science,		20 75
Graduate school,		30 05
Horticultural division: —		
Floriculture,		6,881 34
Forestry,		1,187 12
General horticulture,		9,549 05
Grounds,		514 35
Landscape gardening,		4,812 23
Market gardening,		1,209 57
Pomology,		4,081 26
Humanities, division of: —		
Economics and sociology,		97 87
Language and literature,		279 85
Library,		72,608 85
Military,		1,492 42
Operating and maintenance: —		
College supply,		290 85
Fire apparatus,		1,490 50
General maintenance,		74,063 63
Equipment,	$66,828 06	

Operating and maintenance — *Con.*		
Carpentry and masonry supplies,	$2,003 62	
Electrical supplies,	1,580 28	
Heating and plumbing supplies,	2,956 50	
Painting supplies,	695 17	
Janitors' supplies,		278 67
Sewer line,		8,000 00
Water mains,		8,282 00
Physical education,		2,426 19
Rural social science: —		
Agricultural economics,		353 00
Agricultural education,		834 91
Rural social service,		101 75
Textbooks,		546 89
Trophy room,		1,617 10
		$328,301 68

Experiment Station Buildings (Estimated Value).

Agricultural laboratory,	$15,000 00
Agricultural barns,	5,000 00
Agricultural farmhouse,	1,500 00
Agricultural glass house,	500 00
Cranberry buildings,	2,800 00
Plant and animal chemistry laboratory,	30,000 00
Plant and animal chemistry barns,	4,000 00
Plant and animal chemistry dairy,	2,000 00
Six poultry houses,	600 00
Entomological laboratory and glass house,	850 00
	$62,250 00

Experiment Station Equipment (Estimated Value).

Agricultural laboratory,	$6,443 79
Botanical laboratory,	5,469 26
Chemical laboratory,	18,297 17
Cranberry station,	2,867 70
Director's office,	3,676 61
Entomological laboratory,	23,457 05
Horticultural laboratory,	1,788 00
Meteorology laboratory,	1,102 00
Poultry department,	1,429 25
Treasurer's office,	724 00
Veterinary laboratory,	65 00
	$65,319 83

Inventory Summary.

Land,	$80,792 99
College buildings,	632,800 00
College equipment,	328,301 68
Experiment station buildings,	62,250 00
Experiment station equipment,	65,319 83
	$1,169,464 50

Students' Trust Fund Accounts.

	Disbursements for Year ending Nov. 30, 1913.	Receipts for Year ending Nov. 30, 1913.	Balance on Hand Nov. 30, 1913.	Balance brought forward Dec. 1, 1912.
Athletics,	$8,804 19	$8,360 53	$2,305 69	$2,749 35
"College Signal,"	1,961 63	1,768 75	415 95	608 83
Harlow Farm,	107 12	248 20	-	—141 08
Kellogg Farm,	376 98	352 41	-	24 57
Draper hall,	50,900 06	51,866 36	223 51	—742 79
Keys,	36 50	74 00	69 25	31 75
Student deposits,	9,092 16	9,688 07	2,477 65	1,881 74
Textbooks,	5,376 43	5,415 72	466 22	426 93
Uniforms,	2,854 21	4,355 96	4,135 40	2,633 65
1913 index,	302 50	281 50	7 42	28 42
1914 index,	1,553 01	1,533 40	5 36	24 97
1915 index,	67 58	104 50	36 92	-
Social Union,	773 06	681 91	531 77	622 92
Track suits,	328 05	328 05	-	-
	$82,533 48	$85,059 36	$10,675 14	$9,033 13
Balance on hand Dec. 1, 1912,	-	8,149 26	-	—883 87
Balance on hand Nov. 30, 1913,	10,675 14	-	-	-
	$93,208 62	$93,208 62	$10,675 14	$8,149 26

Detailed Statement of the Dining Hall.

	Liabilities.	Resources.
Dec. 1, 1912, overdraft,	—$742 79	-
Nov. 30, 1913, total disbursements,	50,900 06	-
Nov. 30, 1913, outstanding bills,	1,983 05	-
Nov. 30, 1913, total collections,	-	$51,866 36
Nov. 30, 1913, accounts outstanding,	-	387 88
Nov. 30, 1913, inventory,	-	2,364 43
Nov. 30, 1913, balance,	992 77	-
	$54,618 67	$54,618 67

Endowment Fund.[1]

	Principal.	Income.
United States grant (5 per cent.),	$219,000 00	$7,300 00
Commonwealth grant (3½ per cent.),	142,000 00	3,313 32
		$10,613 32

[1] This fund is in the hands of the State Treasurer, and the Massachusetts Agricultural College receives two-thirds of the income from the same.

Beneficiary Funds.

Burnham Emergency Fund.

	Market Value Dec. 1, 1913.	Par Value.	Income.
Two bonds American Telephone and Telegraph Company 4s, at $850,	$1,700 00	$2,000 00	$80 00
Two bonds Western Electric Company 5s, at $1,000,	2,000 00	2,000 00	100 00
	$3,700 00	$4,000 00	$180 00
Overdraft Dec. 1, 1912,	-	-	—219 45
Overdraft Nov. 30, 1913,			—$39 45

Library Fund.

Five bonds New York Central & Hudson River Railroad Company 4s, at $880,	$4,400 00	$5,000 00	$200 00
Five bonds Lake Shore & Michigan Southern Railroad Company 4s, at $900,	4,500 00	5,000 00	200 00
Two shares New York Central & Hudson River Railroad Company stock, at $96,	192 00	200 00	10 50
Amherst Savings Bank, deposit,	167 77	167 77	6 18
	$9,259 77	$10,367 77	$416 68
Transferred to college library account,	-	-	416 68

Special Funds.

Endowed Labor Fund (the Gift of a Friend of the College).

Two bonds American Telephone and Telegraph Company 4s, at $850,	$1,700 00	$2,000 00	$80 00
Two bonds, Lake Shore & Michigan Southern Railroad Company 4s, at $900,	1,800 00	2,000 00	80 00
One bond New York Central Railroad debenture 4s,	880 00	1,000 00	40 00
Amherst Savings Bank, deposit,	143 39	143 39	5 72
One bond Metropolitan Street Railway, Kansas City, Company 5s, at,	940 00	1,000 00	50 00
	$5,463 39	$6,143 39	$255 72
Unexpended balance Dec. 1, 1912,	-	-	503 11
Cash on hand Dec. 1, 1913,	-	-	$758 83

Whiting Street Scholarship Fund.

One bond New York Central debenture 4s,	$880 00	$1,000 00	$40 00
Amherst Savings Bank, deposit,	271 64	271 64	10 84
	$1,051 64	$1,271 64	$50 84
Unexpended balance Dec. 1, 1912,	-	-	46 31
	-	-	$97 15
Disbursements for scholarships for fiscal year ending Nov. 30, 1913,	-	-	12 50
Cash on hand Dec. 1, 1913,	-	-	$84 65

Hills Fund.

	Market Value Dec. 1, 1913.	Par Value.	Income.
One bond American Telephone and Telegraph Company 4s, at	$850 00	$1,000 00	$40 00
One bond New York Central & Hudson River Railroad debenture 4s, at	880 00	1,000 00	40 00
One bond New York Central & Hudson River Railroad debenture 3½s, at	780 00	1,000 00	35 00
Two bonds Metropolitan Street Railway of Kansas City 5s, at $940,	1,880 00	2,000 00	100 00
Three bonds Pacific Telephone and Telegraph Company 5s, at $960,	2,880 00	3,000 00	150 00
One bond Western Electric Company 5s, at	1,000 00	1,000 00	50 00
Boston & Albany Railroad stocks, 3⅝ shares, at $200,	725 00	362 50	31 68
Amherst Savings Bank, deposit,	72 75	72 75	2 88
Electric Securities Company bonds, 1⁹/₅₀, at $1,000,	1,180 00	1,180 00	59 00
Electric Securities Company bonds exchanged for series No. 12,	–	–	35 40
	$10,247 75	$10,615 25	$543 96
Unexpended balance Dec. 1, 1912,	–	–	112 58
	–	–	$656 54
Disbursements by floriculture and botanical departments for fiscal year ending Nov. 30, 1913,	–	–	112 20
Cash on hand Dec. 1, 1913,	–	–	$544 34

Mary Robinson Fund.

Boston & Albany Railroad stock, ⅜ share at $200,	$75 00	$38 00	$3 32
Electric Securities Company bonds, ⁴¹/₅₀ share at $1,000,	820 00	820 00	41 00
Electric Securities Company bonds, exchanged for series No. 12,	–	–	24 60
	$895 00	$858 00	$68 92
Unexpended balance Dec. 1, 1912,	–	–	99 40
	–	–	$168 32
Disbursements for fiscal year ending Nov. 30, 1913,	–	–	43 00
Cash on hand Dec. 1, 1913,	–	–	$125 32

Grinnell Prize Fund.

Ten shares New York Central & Hudson River Railroad stock, at $96,	$960 00	$1,000 00	$50 00
Unexpended balance Dec. 1, 1912,	–	–	195 74
	–	–	$245 74
Disbursements for prizes,	–	–	50 00
Cash on hand Dec. 1, 1913,	–	–	$195 74

Massachusetts Agricultural College (Investment).

One share New York Central & Hudson River Railroad stock,	$96 00	$100 00	$5 00
Unexpended balance Dec. 1, 1912,	–	–	60 45
Cash on hand Dec. 1, 1913,	–	–	$65 45

Gassett Scholarship Fund.

	Market Value Dec. 1, 1913.	Par Value.	Income.
One bond New York Central & Hudson River Railroad debenture 4s,	$880 00	$1,000 00	$40 00
Amherst Savings Bank, deposit,	11 64	11 64	44
	$891 64	$1,011 64	$40 44
Unexpended balance Dec. 1, 1912,	–	–	30 95
Cash on hand Dec. 1, 1913,	–	–	$71 39

Danforth Keyes Bangs Fund.

Two bonds Pacific Telephone and Telegraph Company 5s, at $960,		$1,920 00	$2,000 00	$100 00
Two bonds Union Electric Light and Power Company 5s, at $950,		1,900 00	2,000 00	100 00
Two bonds American Telephone and Telegraph Company 4s, at $850,		1,700 00	2,000 00	80 00
Interest from student loans,		–	–	16 83
		$5,520 00	$6,000 00	$296 83
Unexpended balance Dec. 1, 1912,		–	–	402 02
		–	–	$698 85
Total loans made to students during fiscal year,	$1,084 75			
Cash received on account of student loans,	766 25			
Excess of loans made, over accounts paid by students,				318 50
Cash on hand Dec. 1, 1913,				$380 35

John C. Cutter Fund.

One bond Pacific Telephone and Telegraph Company 5s,	$960 00	$1,000 00	$50 00
Unexpended balance Dec. 1, 1912,	–	–	74 72
	–	–	$124 72
Disbursements for fiscal year to date,	–	–	111 60
Cash on hand Dec. 1, 1913,	–	–	$13 12

Summary of Balances on Hand of the Income from Funds held in Trust by the Massachusetts Agricultural College.

Endowed labor fund,	$758 83
Whiting Street scholarship fund,	84 65
Hills fund,	544 34
Mary Robinson fund,	125 32
Grinnell Prize fund,	195 74
Gassett scholarship fund,	71 39
Massachusetts Agricultural College investment fund,	65 45
Danforth Keyes Bangs fund,	380 35
John C. Cutter fund,	13 12
	$2,239 19
Burnham emergency fund overdraft,	39 45
	$2,199 74

I hereby certify that I have this day examined the Massachusetts Agricultural College account, as reported by the treasurer, Fred C. Kenney, for the year ending Nov. 30, 1913. All bonds and investments are as represented in the treasurer's report. All disbursements are properly vouched for, and all cash balances are found to be correct.

CHARLES A. GLEASON,
Auditor.

Amherst, Dec. 15, 1913.

History of Special Funds.

Burnham emergency fund: —	
A bequest of $5,000 from T. O. H. P. Burnham of Boston, made without any conditions. The trustees of the college directed that $1,000 of this fund should be used in the purchase of the Newell land and Goessmann library. The fund now shows an investment of	$4,000 00
Library fund: —	
The library of the college at the present time contains about 41,000 volumes. The income from the fund raised by the alumni and others is devoted to its increase, and additions are made from time to time as the needs of the different departments require. Dec. 27, 1883, William Knowlton gave $2,000; Jan. 1, 1894, Charles L. Flint gave $1,000; in 1887 Elizur Smith of Lee, Mass., gave $1,215. These were the largest bequests, and now amount to	10,000 00
Endowed labor fund: —	
Gift of a friend of the college in 1901, income of which is to be used for the assistance of needy and deserving students,	5,000 00

Whiting Street scholarship: —	
Gift of Whiting Street of Northampton, for no special purpose, but to be invested and the income used. This fund is now used exclusively for scholarship, .	$1,000 00
Hills fund: —	
Gift of Leonard M. and Henry F. Hills of Amherst, Mass., in 1867, to establish and maintain a botanic garden,	10,000 00
Mary Robinson fund: —	
Gift of Miss Mary Robinson of Medfield, in 1874, for scholarship, ...	1,000 00
Grinnell prize fund: —	
Gift of Hon. Wm. Claflin, to be known as the Grinnell agricultural prize, to be given to the two members of the graduating class who may pass the best oral and written examination in theory and practice of agriculture, given in honor of George B. Grinnell of New York, ...	1,000 00
Gassett scholarship fund: —	
Gift of Henry Gassett of Boston, the income to be used for scholarship, ...	1,000 00
Massachusetts Agricultural College investment fund: —	
Investment made by vote of trustees in 1893; to purchase one share of New York Central & Hudson River Railroad stock. The income from this fund has been allowed to accumulate, ...	100 00
Danforth Keyes Bangs fund: —	
Gift of Louisa A. Baker of Amherst, Mass., April 14, 1909, the income thereof to be used annually in aiding poor, industrious and deserving students to obtain an education in said college, ...	6,000 00
John C. Cutter fund: —	
Gift of Dr. John C. Cutter of Worcester, Mass., an alumnus of the college, who died in August, 1909, to be invested by the trustees, and the income to be annually used for the purchase of books on hygiene, ...	1,000 00
	$41,100 00

Prizes.

Sophomore prize in botany, given by Prof. A. V. Osmun of the department of botany to that member of the sophomore class who presents the best herbarium in the regular course (this prize was first offered in 1908 with the hope that it might stimulate a greater interest on the part of the students in this line of work), ...	$5 00

Special prize, given by the Western Alumni Association to that member of the sophomore class who during his first two years has shown the greatest improvement in scholarship, character and example, ...	$25 00
Animal husbandry. The F. Lothrup Ames prize, given by F. Lothrup Ames, Langwater Farms, North Easton, Mass., consisting of $150 a year, offered for a period of five years, to be given to the three students standing highest in the work of advanced live stock judging, and to be used in defraying their expenses incurred by participation in the students' judging contest at the National Dairy Show, Chicago. Given in May, 1912, available first in autumn of 1912, and for the four succeeding years, ...	150 00
	$180 00

FRED C. KENNEY,
Treasurer.

THE M. A. C. BULLETIN

AMHERST, MASS.

Vol VI. No. 1. For January, 1914

Published Six Times a Year by the College,
Jan., Feb., Mar., May, Sept., Oct.

ENTERED AS SECOND-CLASS MAIL MATTER AT THE POST OFFICE, AMHERST, MASS.

Public Document No. 31

CATALOGUE

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE, 1913-1914.

FIFTY-FIRST ANNUAL REPORT.

PART II.

BOSTON:
WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
32 DERNE STREET.
1914.

Without excluding other scientific and classical studies, and including military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts in such manner as the legislatures of the states may respectively prescribe, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life.—*Act of Congress, July 2, 1862.*

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST.

CATALOGUE, 1913-1914.

BOSTON:
WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
32 DERNE STREET.
1914.

Approved by
The State Board of Publication.

The Massachusetts Agricultural College.

This issue of the catalogue represents the status of the college for the current college year, with provisional announcement of courses of study and other matters for the year to follow.

The college reserves, for itself and its departments, the right to withdraw or change the announcements made in its catalogue. Special publication will be made should it become necessary on account of important changes.

CALENDAR.

1914-15.

REGULAR COURSES.

1914.

January 5, Monday, 1 P.M.,	Winter recess ends; regular schedule of classes.
January 23, Friday, 8 A.M.,	Semester examinations begin.
February 2, Monday, 1 P.M.,	Second semester begins; regular schedule of classes.
February 23, Monday forenoon,	Half holiday, observance of Washington's Birthday.
March 27, Friday, 5 P.M.,	Spring recess begins.
April 6, Monday, 1 P.M.,	Spring recess ends; regular schedule of classes.
April 20, Monday forenoon,	Half holiday, observance of Patriots' Day.
May 30, Saturday,	Holiday, Memorial Day.
June 1, Monday, 8 A.M.,	Senior and junior examinations begin.
June 6, Saturday, 8 A.M.,	Sophomore and freshman examinations begin.
June 13–17, Saturday–Wednesday,	Commencement.
June 18–20, Thursday–Saturday,	Entrance examinations.
September 2–5, Wednesday–Saturday,	Entrance examinations.
September 9, Wednesday, 1.30 P.M.,	First semester begins; chapel.
October 12, Monday forenoon,	Half holiday, Columbus Day.
November 25–November 30, Wednesday, 12 M.–Monday 1 P.M.,	Thanksgiving recess; regular schedule of classes.
December 18, Friday, 5 P.M.,	Winter recess begins.

1915.

January 4, Monday, 1 P.M.,	Winter recess ends; regular schedule of classes.
January 22, Friday, 8 A.M.,	Semester examinations begin.
February 1, Monday, 1 P.M.,	Second semester begins; regular schedule of classes.
February 22, Monday forenoon,	Half holiday, Washington's Birthday.
March 26, Friday, 5 P.M.,	Spring recess begins.
April 5, Monday, 1 P.M.,	Spring recess ends; regular schedule of classes.
April 19, Monday forenoon,	Half holiday, Patriots' Day.
May 31, Monday,	Holiday, observance of Memorial Day.
June 1, Tuesday, 8 A.M.,	Senior and junior examinations begin.
June 5, Saturday, 8 A.M.,	Sophomore and freshman examinations begin.
June 12–16, Saturday–Wednesday,	Commencement.
June 17–19, Thursday–Saturday,	Entrance examinations.

Massachusetts Agricultural College.

History. — The Massachusetts Agricultural College was among the first of those organized under the national land grant act of 1862. This act granted public lands to the several States and Territories, the funds realized from the sale of which should be used to establish colleges of agriculture and mechanic arts; the bill was framed by the late Senator Justin Smith Morrill of Vermont. The Legislature of Massachusetts has granted money for the erection of nearly all the buildings now on the grounds, and makes annual appropriations for the maintenance of the college.

The college was incorporated in 1863, and on the 2d of October, 1867, was formally opened to its first class of students. At that time four buildings had been erected, and there were four regular instructors employed by the institution. In 1882 the State located its agricultural experiment station on the grounds of the college. Later, after the federal law was passed granting financial aid to experiment stations, the Massachusetts Agricultural Experiment Station was consolidated with the federal station, and subsequently the whole was incorporated with the college.

Courses. — The college offers an education without tuition fee to any student who is a resident of Massachusetts and who meets the requirements for admission. Women are admitted on the same basis as are men. Students who are not residents of Massachusetts are required to pay a nominal tuition fee. The four-years [1] course leads to the degree of bachelor of science, and the graduate school offers advanced courses leading to the degrees of master of science and doctor of philosophy. The winter school of ten weeks, for admission to which no scholastic requirements are made, is held each winter, beginning early in January. There are other short courses at the college, such as the beekeepers' course and summer school. Various forms of extension teaching are carried on away from the college, such as correspondence courses, traveling schools, educational exhibits, lecture courses, demonstrations, and circulating libraries.

Purpose of the College. — The chief purpose of the college is to prepare men and women for the agricultural vocations. In this statement the term "agricultural vocations" is used in its broadest sense. Courses are offered which give efficient training in various agricultural pursuits, such as general farming, dairying, management of estates, poultry husbandry, fruit growing, market gardening, landscape gardening and forestry. Students are also fitted for positions in institutions designed for investigation in many sciences underlying the great agricultural industry, for teaching in agricultural colleges and high schools, for scientific experts in chemistry, entomology,

[1] Twenty-six teaching departments offer instruction in agriculture, horticulture, sciences, the humanities and rural social science. A system of major courses permits a student to elect work in 1 of 14 departments and to specialize in that and allied subjects for a period of two years.

botany and microbiology and for business operations having connection with practical agriculture.

Though the agricultural vocations are thus the chief concern of the college, students also find the course one that fits them admirably for pursuits in which the sciences, particularly chemistry, botany and zoölogy, are an essential preparation. Still other students find the course a desirable education, without regard to future occupation. The course of study is designed to give a student a general college education, and in addition to make it possible for him to specialize in any department in which a major course is offered.

Location and Equipment. — The agricultural college is located in the town of Amherst. The grounds comprise more than 600 acres, lying about a mile north of the village center. The equipment of the college, both in buildings and facilities for instruction, is excellent. Amherst is about 98 miles from Boston, and may be reached over the Central Massachusetts division of the Boston & Maine Railroad, or by way of the Central Vermont Railroad. Electric car lines connect Amherst with Northampton, Holyoke and Springfield.

The Massachusetts Agricultural Experiment Station.

Massachusetts provided for the establishment of an agricultural experiment station in 1882. This station, though on the college grounds and supported by the State, was then without organic connection with the college. Under an act of Congress, passed in 1887, an agricultural experiment station was established as a department of the college, and was supported by the general government. For a time, therefore, Massachusetts had two experiment stations at the college. In 1894 these were combined, and the station reorganized as a department of the college. It is now supported by funds from both the State and the general government. In 1906 the general government largely increased its support of experiment stations, on condition, however, that the money thus provided should be used only for research. The station now receives about one-third of its support from the State.

The station is under the direct supervision of the Board of Trustees. The chief officer is the director, who is responsible to the president and to a committee of the Board. The station is organized into a number of departments, all co-operating toward the betterment of agriculture. In most cases the heads of the station departments are heads of corresponding departments in the college. The work of the station takes three directions; namely, control work, experimentation and investigation. The station publishes numerous bulletins and two annual reports, one scientific, the other for practical farmers and for general distribution. These publications, conveying information as to results of experiments, are free, and circulate extensively, the mailing list containing some 20,000 addresses.

The Corporation.

Members of the Corporation.

	Term expires
Charles E. Ward of Buckland,	1914
Elmer D. Howe of Marlborough,	1914
Nathaniel I. Bowditch of Framingham,	1915
William Wheeler of Concord,	1915
Arthur G. Pollard of Lowell,	1916
Charles A. Gleason of New Braintree,	1916
Frank Gerrett of Greenfield,	1917
Harold L. Frost of Arlington,	1917
Charles H. Preston of Danvers,	1918
Frank A. Hosmer of Amherst,	1918
Davis R. Dewey of Cambridge,	1919
George P. O'Donnell of Northampton,	1919
William H. Bowker of Concord,	1920
George H. Ellis of West Newton,	1920

Members Ex Officio.

His Excellency Governor David I. Walsh, *President of the Corporation.*
Kenyon L. Butterfield, *President of the College.*
David Snedden, *State Commissioner of Education.*
Wilfrid Wheeler, *Secretary of the State Board of Agriculture.*

Officers of the Corporation.

His Excellency Governor David I. Walsh, of Boston, *President.*
Charles A. Gleason of New Braintree, *Vice-President.*
Wilfrid Wheeler of Concord, *Secretary.*
Fred C. Kenney of Amherst, *Treasurer.*
Charles A. Gleason of New Braintree, *Auditor.*

Standing Committees of the Corporation.[1]

Committee on Finance.

Charles A. Gleason, *Chairman.*
George H. Ellis.
Nathaniel I. Bowditch.
Arthur G. Pollard.
Charles E. Ward.
Frank A. Hosmer.

Committee on Course of Study and Faculty.

William Wheeler, *Chairman.*
William H. Bowker.
Frank A. Hosmer.
David Snedden.
Elmer D. Howe.
Davis R. Dewey.
George P. O'Donnell.

Committee on Farm.

Nathaniel I. Bowditch, *Chairman.*
Frank Gerrett.
Charles A. Gleason.
George H. Ellis.

[1] The president of the college is *ex officio* member and secretary of standing committees.

Committee on Horticulture.

Wilfrid Wheeler, *Chairman.*
Davis R. Dewey.
Elmer D. Howe.
Harold L. Frost.

Committee on Experiment Department.[1]

Charles H. Preston, *Chairman.*
Wilfrid Wheeler.
Arthur G. Pollard.
Charles E. Ward.
Harold L. Frost.

Committee on Buildings and Arrangement of Grounds.

William H. Bowker, *Chairman.*
William Wheeler.
Frank Gerrett.
Charles H. Preston.
George P. O'Donnell.

Committee on Extension Service.

Elmer D. Howe, *Chairman.*
George H. Ellis.
Charles E. Ward.
Wilfrid Wheeler.
Harold L. Frost.

Examining Committee of Overseers from the State Board of Agriculture.

John Bursley of West Barnstable.
Frank P. Newkirk of Easthampton.
William E. Patrick of Warren.
John J. Erwin of Wayland.
R. Henry Race of North Egremont.

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[1] The director of the experiment station is a member of the committee on experiment department, without vote.

Officers of the Institution.

[The names of the faculty are arranged in groups according to rank. Within these groups, the order depends upon seniority of service in the college, not upon seniority of appointment to the position now held.]

THE FACULTY.

Kenyon L. Butterfield,[1] A.M., LL.D., ... President's House.
President of the College and Head of Division of Rural Social Science.

George F. Mills, A.M., ... 46 Amity Street.
Dean of the College and Professor of Languages and Literature.

Charles H. Fernald, Ph.D., ... 3 Hallock Street.
Honorary Director of the Graduate School.

William P. Brooks, Ph.D., ... 5 Farview Way.
Director of the Experiment Station and Lecturer on Soil Fertility.

William D. Hurd, M.Agr., ... 82 Pleasant Street.
Director of the Extension Service.

Charles E. Marshall, Ph.D., ... Sunset Avenue.
Director of the Graduate School and Professor of Microbiology.

Frank A. Waugh, M.Sc., ... Campus.
Head of Division of Horticulture and Professor of Landscape Gardening.

James A. Foord, M.Sc.Agr., ... Lincoln Avenue.
Head of Division of Agriculture and Professor of Farm Administration.

Robert J. Sprague, Ph.D., ... Mount Pleasant.
Head of Division of the Humanities and Professor of Economics and Sociology.

Joseph B. Lindsey, Ph.D., ... 47 Lincoln Avenue.
Goessmann Professor of Chemistry.

Charles Wellington, Ph.D., ... 34 Amity Street.
Professor of Chemistry.

James B. Paige, B.Sc., D.V.S., ... 42 Lincoln Avenue.
Professor of Veterinary Science.

George E. Stone, Ph.D., ... Mount Pleasant.
Professor of Botany.

Philip B. Hasbrouck, B.Sc., ... 130 Pleasant Street.
Professor of Physics and Registrar of the College.

John E. Ostrander, A.M., C.E., ... 33 North Prospect Street.
Professor of Mathematics and Civil Engineering.

Henry T. Fernald, Ph.D., ... 44 Amity Street.
Professor of Entomology, Chairman of Division of Science.

George C. Martin, C.E., Captain 18th U. S. Infantry, ... Amherst House.
Professor of Military Science and Tactics.

—— ——[2] . . . . – –
Professor of Floriculture.

William R. Hart, A.M., L.B., ... 97 Pleasant Street.
Professor of Agricultural Education.

Fred C. Sears, M.Sc., ... Mount Pleasant.
Professor of Pomology.

Fred C. Kenney, ... Mount Pleasant.
Treasurer of the College.

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[1] On leave of absence; Associate Dean Lewis serving as acting president.

[2] Position being filled temporarily by Mr. Edward J. Canning of Northampton.

JOSEPH S. CHAMBERLAIN, Ph.D., Professor of Organic and Agricultural Chemistry.	Mount Pleasant.
WILLIAM P. B. LOCKWOOD, M.Sc., Professor of Dairying.	7 East Pleasant Street.
JOHN C. GRAHAM, B.Sc., Professor of Poultry Husbandry.	Lincoln Avenue.
EDWARD M. LEWIS, A.M., Associate Dean of the College and Professor of Literature.	Lincoln Avenue and Gaylord Street.
WILLIAM D. CLARK, A.B., M.F., Professor of Forestry.	25 North Prospect Street.
SIDNEY B. HASKELL, B.Sc., Associate Professor of Agronomy.	5 Fearing Street.
ROBERT W. NEAL,[1] A.M., Associate Professor of English.	– –
CLARENCE E. GORDON, Ph.D., Associate Professor of Zoölogy and Geology.	38 Lincoln Avenue.
ALEXANDER E. CANCE, Ph.D., Associate Professor of Agricultural Economics.	9 Fearing Street.
ELMER K. EYERLY, A.M., Associate Professor of Rural Sociology.	52 Amity Street.
JOHN A. McLEAN, A.B., B.Sc.Agr., Associate Professor of Animal Husbandry.	Lincoln Block.
G. CHESTER CRAMPTON, Ph.D., Associate Professor of Entomology.	86 Pleasant Street.
CHARLES A. PETERS, Ph.D., Associate Professor of Inorganic and Soil Chemistry.	South Sunset Avenue.
GEORGE E. GAGE, Ph.D., Associate Professor of Animal Pathology.	27 Sunset Avenue.
A. VINCENT OSMUN, M.Sc., Assistant Professor of Botany.	5 Kendrick Place.
EDGAR L. ASHLEY, A.M., Assistant Professor of German.	Prospect House.
ANDERSON A. MACKIMMIE, A.B., Assistant Professor of French.	Pine Street, North Amherst.
BURTON N. GATES, Ph.D., Assistant Professor of Beekeeping.	42 Lincoln Avenue.
CURRY S. HICKS, B.Pd., Assistant Professor of Physical Education and Hygiene.	8 Allen Street.
ARTHUR K. HARRISON, Assistant Professor of Landscape Gardening.	8 Allen Street.
ERNEST ANDERSON, Ph.D., Assistant Professor of General and Physical Chemistry.	17 Phillips Street.
HENRY E. SMITH, A.M., Assistant Professor of English.	24 Pleasant Street.
WALTER W. CHENOWETH, A.B., M.Sc., Assistant Professor of Pomology.	North Amherst.
ELMER M. McDONALD, B.Sc., Assistant Professor of Agronomy.	24 Pleasant Street.
F. H. HESSELINK VAN SUCHTELEN, Ph.D., Assistant Professor of Microbiology.	75 Pleasant Street.
HAROLD E. ROBBINS, B.Sc., A.M., Assistant Professor of Physics.	12 Nutting Avenue.
GEORGE N. HOLCOMB,[2] A.B., S.T.B., Lecturer in History.	– –
FRANK W. RANE, M.F., Lecturer in Forestry.	Boston.
CHARLES R. GREEN, B.Agr., Librarian.	Mount Pleasant.
C. ROBERT DUNCAN, B.Sc., Instructor in Mathematics.	31 North Prospect Street.
WILLARD A. WATTLES, A.M., Instructor in English.	24 Pleasant Street.

[1] On leave of absence. [2] Resigned, to take effect Nov. 1, 1913.

William L. Harmount, A.B., ... 86 Pleasant Street.
Instructor in French.
Elvin L. Quaife, B.Sc.Agr., ... 13 Fearing Street.
Instructor in Animal Husbandry.
William L. Machmer, A.M., M.E., ... 3 Kendrick Place.
Instructor in Mathematics.
Arthur N. Julian, A.B., ... Farview Way.
Instructor in German.
Walter E. Prince, Ph.B., A.M., ... 13 Spring Street.
Instructor in English and Public Speaking.
Adrian A. Brown, B.Sc., ... 24 Pleasant Street.
Instructor in Poultry Husbandry.
Samuel Coons, ... 56 Pleasant Street.
Buttermaker.
Bert C. Georgia, B.Sc., ... 24 Pleasant Street.
Instructor in Market Gardening.
Frank N. Blanchard, A.B., ... 9 Fearing Street.
Instructor in Zoölogy and Geology.
Miss Helena T. Goessmann, Ph.M., ... 40 Amity Street.
Assistant in English.
Frederick A. McLaughlin, B.Sc., ... Clark Hall.
Assistant in Botany.
Raymond G. Smith, B.Sc., ... Clark Hall.
Assistant in Botany.
Robert H. Bogue, B.Sc., ... Meadow Street, North Amherst.
Assistant in Chemistry.
William J. Fitzmaurice, ... – –
Assistant in Physical Education.
Harold M. Gore, B.Sc., ... 24 Pleasant Street.
Assistant in Physical Education.
Burt A. Hazeltine, B.Sc., ... 4 North Prospect Street.
Assistant in Mathematics.

Graduate Assistants.

Charles G. Baird, A.M., ... 9 Fearing Street.
Department of Agricultural Economics.
Henry L. Brown, B.Sc., ... 120 Pleasant Street.
Department of Chemistry.
Ernest L. Davies, B.Sc.Agr., ... 77 Pleasant Street.
Department of Microbiology.
G. Scott Fowler, B.Sc., ... 24 Pleasant Street.
Department of Chemistry.
Walter H. Hillary, B.Sc., ... Wilder Hall.
Department of Landscape Gardening.
Arao Itano, B.Sc., ... 75 Pleasant Street.
Department of Microbiology.
Russell F. Lund, A.B., ... Pine Heights.
Department of Agronomy.
James F. Martin, B.Sc., ... 19 South East Street.
Department of Entomology.
Harold A. Robinson, B.Sc., ... 6 Allen Street.
Department of Chemistry.
Paul Serex, Jr., B.Sc., ... Chemical Laboratory.
Department of Chemistry.
Carl J. Strand, A.M., ... 77 Pleasant Street.
Department of Rural Sociology.
Clark L. Thayer, B.Sc., ... 92 Pleasant Street.
Department of Floriculture.

Other College Officers.

Ralph J. Watts, B.Sc., ... 10 Nutting Avenue.
Secretary to the President.
Harold A. Crane, ... 4 Nutting Avenue.
Cashier.

Newton Wallace, ... Campus.
Electrician.
Percy C. Schroyer, ... 6 Phillips Street.
Assistant Engineer.
Clarence A. Jewett, ... 112 Pleasant Street.
Superintendent of Buildings.
James Whiting, ... 16 Hallock Street.
Foreman, Department of Floriculture.
John J. Lee, Sergeant, ... 9 Phillips Street.
Assistant to the Military Detail.
John J. Barber, ... Campus.
Farm Superintendent.
Lawrence S. Dickinson, B.Sc., ... Campus.
Foreman of Grounds.
John L. Byard, ... 21 Pleasant Street.
Superintendent of the Apiary.
William Chesley, ... Draper Hall.
Steward of the Dining Hall.
Miss Bertha E. Christiansen, A.B., ... 9 Phillips Street.
Assistant to the Dean.
Miss Lorian P. Jefferson, A.M., ... 84 Pleasant Street.
Expert Secretary, Division of Rural Social Science.
Miss Mary E. Caldwell, ... Draper Hall.
Bookkeeper.
Miss Henrietta L. Webster, ... Draper Hall.
Clerk, Treasurer's Office.
Miss Dorothy Mudge, ... Draper Hall.
Stenographer, Treasurer's Office.
Miss Lillian M. Gelinas, ... 79 Pleasant Street.
Stenographer, President's Office.
—— —— . . . . – –
Clerk, President's Office.
Miss Alice M. Gilbert, ... Draper Hall.
Clerk, Department of Dairying.
Miss Luliona M. Barker, A.M., B.Sc., ... 9 Phillips Street.
Clerk, Department of Farm Administration.
Miss Lina E. Fisher, ... 28 Pleasant Street.
Stenographer, Department of Chemistry.
Miss Gladys E. Russell, A.B., ... Draper Hall.
Clerk, Division of Horticulture.
Miss Ada M. Chandler, A.B., ... 3 Fearing Street.
Cataloguing Clerk, Library.
Miss Marion Guertin, ... 5 East Pleasant Street.
Stenographer, Department of Entomology.
Miss Olive M. Turner, B.Sc., ... 22 Spaulding Street.
Clerk, Registrar's Office.
Miss Dorothy F. Smith, ... Draper Hall.
Clerk, Department of Floriculture.
Miss Lena Chapman, ... 6 Maple Avenue.
Library Assistant.
Miss Nell C. Milton, ... Draper Hall.
Stenographer, Division of Rural Social Science.
Miss Clarissa G. Babcock, B.Sc., ... 9 Phillips Street.
Clerk, Library.
Miss Esther L. Houghton, A.B., ... 52 Pleasant Street.
Clerk, Department of Microbiology and Division of Agriculture.
Miss Rebecca L. Mellor,[1] . . . . 7 Northampton Road.
Clerk, Division of the Humanities.

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[1] Half time.

THE EXPERIMENT STATION STAFF.

William P. Brooks, Ph.D., ... 5 Farview Way.
Director.
Joseph B. Lindsey, Ph.D., ... 47 Lincoln Avenue.
Vice-Director.
Fred C. Kenney, ... Mount Pleasant.
Treasurer.
Charles R. Green, B.Agr., ... Mount Pleasant.
Librarian.
Mrs. Lucia G. Church, ... 4 Hallock Street.
First Clerk, Office of the Director.
Miss Grace E. Gallond, ... 28 Pleasant Street.
Stenographer, Office of the Director.

Department of Plant and Animal Chemistry.

Joseph B. Lindsey, Ph.D., ... 47 Lincoln Avenue.
Chemist.
Edward B. Holland, M.Sc., ... 28 North Prospect Street.
Associate Chemist, in charge of Research Division.
Fred W. Morse, M.Sc., ... 40 Pleasant Street.
Research Chemist.
Henri D. Haskins, B.Sc., ... 14 Amity Street.
In charge of Fertilizer Division.
Philip H. Smith, M.Sc., ... 102 Main Street.
In charge of Feed and Dairy Division.
Lewell S. Walker, B.Sc., ... 19 Phillips Street.
Assistant.
Rudolph W. Ruprecht, B.Sc., ... 32 North Prospect Street.
Assistant.
Carleton P. Jones, M.Sc., ... 30 North Prospect Street.
Assistant.
Carlos L. Beals, B.Sc., ... 92 Pleasant Street.
Assistant.
Walter S. Frost, B.Sc., ... 4 North Prospect Street.
Assistant.
James P. Buckley, Jr., ... 29 Lincoln Avenue.
Assistant.
James T. Howard, ... North Amherst.
Collector.
Harry L. Allen, ... 89 Main Street.
Assistant.
James R. Alcock, ... Hatch Barn.
Assistant.
Miss F. Ethel Felton, A.B., ... 9 Phillips Street.
First Clerk.
Miss Alice M. Howard, ... North Amherst.
Clerk.
Miss Rebecca L. Mellor,[1] . . . . 7 Northampton Road.
Clerk.

Department of Agriculture.

William P. Brooks, Ph.D., ... 5 Farview Way.
Agriculturist.
Henry J. Franklin, Ph.D., ... Wareham.
In charge of Cranberry Investigation.
Edwin F. Gaskill, B.Sc., ... Pleasant Street.
Assistant Agriculturist.
Hubert D. Goodale, Ph.D., ... North Amherst.
Research Biologist in Poultry Husbandry.

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[1] Half time.

John W. Sayer, ... Campus.
Foreman, Poultry Experimental Yards.
Miss Fay L. Milton, ... Draper Hall.
Clerk, Department of Poultry Husbandry.

Department of Horticulture.

Frank A. Waugh, M.Sc., ... Campus.
Horticulturist.
Fred C. Sears, M.Sc., ... Mount Pleasant.
Pomologist.
Jacob K. Shaw, Ph.D., ... 1 Allen Street.
Research Pomologist.
John B. Norton, B.Sc., ... 84 Pleasant Street.
Graduate Assistant.

Department of Botany and Vegetable Pathology.

George E. Stone, Ph.D., ... Mount Pleasant.
Botanist and Plant Pathologist.
George H. Chapman,[1] M.Sc., ... – –
Assistant Botanist.
Edward A. Larrabee, B.Sc., ... Clark Hall.
Assistant Botanist.
Miss Jessie V. Crocker, ... Sunderland.
Clerk.

Department of Entomology.

Henry T. Fernald, Ph.D., ... 44 Amity Street.
Entomologist.
Burton N. Gates, Ph.D., ... 42 Lincoln Avenue.
Apiarist.
Arthur I. Bourne, A.B., ... 12 East Pleasant Street.
Assistant in Entomology.
Miss Bridie E. O'Donnell, ... Hadley.
Clerk.

Department of Veterinary Science.

James B. Paige, B.Sc., D.V.S., ... 42 Lincoln Avenue.
Veterinarian.

Department of Meteorology.

John E. Ostrander, A.M., C.E., ... 33 North Prospect Street.
Meteorologist.

THE EXTENSION SERVICE STAFF.

William D. Hurd, M.Agr., ... 82 Pleasant Street.
Director.
Earnest D. Waid, B.Sc.Agr., ... 61 Amity Street.
Assistant Director.
Orion A. Morton, ... Mount Pleasant.
Extension Professor of Agricultural Education.
Ezra L. Morgan, A.M., ... 2 Allen Street.
Community Field Agent.
Miss Laura Comstock, ... 84 Pleasant Street.
Extension Professor of Home Economics.
George F. E. Story, B.Sc.Agr., ... 10 Allen Street.
Extension Instructor in Dairying and Animal Husbandry.
Ralph W. Rees, A.B., B.Sc., ... 24 Pleasant Street.
Extension Instructor in Pomology.
Herbert J. Baker, B.Sc., ... 24 Pleasant Street.
Field Agent in Farm Management.
Philip H. Elwood, B.Sc.Agr., ... Lincoln Avenue.
Extension Instructor in Civic Improvement.

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[1] On leave of absence; position filled temporarily by Mr. Orton L. Clark.

Erwin H. Forbush, ... 8 Nutting Avenue.
Supervisor of Correspondence Courses.

Allister F. McDougall, B.Sc., ... – –
Demonstrator in charge of Automobile Truck.

Lawrence B. Boston,[1] . . . . Sandwich.
Agricultural Advisor, Barnstable County.

John A. Scheuerle,[1] . . . . Springfield.
Secretary, Hampden County Improvement League.

Miss Mabel R. Case, A.B., ... Draper Hall.
First Clerk.

Miss Hannah M. Griffin, A.B., ... Draper Hall.
Clerk.

Miss Cora B. Grover, ... 4 Hallock Street.
Stenographer.

Miss Marion S. Donaldson, B.Sc., ... Draper Hall.
Stenographer.

Miss Ina M. Paige, ... Draper Hall.
Stenographer.

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[1] Gives part-time service to the Massachusetts Agricultural College.

Standing Committees of the Faculty.[1]

1913-14.

Catalogue and Other Publications.

Associate Professor Eyerly.
Associate Professor Cance.
Assistant Professor Smith.

Commencement.

Professor Paige.
Professor Waugh.
The Commandant.
Associate Professor Peters.
Mr. Kenney.
Mr. Duncan.

Course of Study.

Professor Hart.
Professor Waugh.
Professor Foord.
Professor Sprague.
Professor Fernald.
Professor Ostrander.
Professor Chamberlain.

Discipline (Advisory).

Professor Mills.
Professor Hasbrouck.
Professor Lewis.
Captain Martin.
Associate Professor Gordon.
Assistant Professor Mackimmie.

Employment.

Professor Sears.
Mr. Kenney.
Associate Professor Haskell.

Entrance Examinations and Admission.

Professor Hasbrouck.
Professor Graham.
Assistant Professor Osmun.
Assistant Professor Ashley.
Mr. Machmer.
Mr. Wattles.

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[1] The president of the college is ex officio member of each standing committee.

Graduate School.

Professor Marshall.
Professor Fernald.
Professor Lindsey.
Professor Paige.
Professor Stone.
Professor Sears.
Associate Professor Gordon.

Library.

Professor Stone.
Professor Marshall.
Professor Wellington.
Associate Professor Cance.

Physical Education and Athletics.[1]

No appointments for 1913–14.

Schedule.

Professor Lockwood.
Professor Sprague.
Associate Professor Peters.

Scholarship.

Associate Professor Gordon.
Professor Mills.
Professor Hasbrouck.
Professor Lewis.
Assistant Professor Mackimmie.

Student Life.

Director Hurd.
Professor Chamberlain.
Professor Lewis.
Associate Professor McLean.
Associate Professor Haskell.
Assistant Professor Mackimmie.
Assistant Professor Hicks.

Unclassified Students.

Professor Lockwood.
Professor Sears.
Associate Professor Peters.

Appointed to Athletic Board.

Professor Paige.
Professor Hasbrouck.
Assistant Professor Osmun.

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[1] In lieu of this a committee on health and sanitation is appointed for one year, consisting of Professor Marshall, Mr. Kenney, Professor Lockwood, the Commandant, Miss Comstock and Assistant Professor Hicks.

The College.

Admission.

A. Application for Admission.

All correspondence concerning admission should be addressed to the registrar.

Every applicant for admission to the college must be at least sixteen years old, and must present to the registrar proper testimonials of good character. Such testimonials, whenever possible, should come from the principal of the school at which the applicant has prepared for college. Candidates who desire to present themselves for examination in any subjects must make application to the college for such privilege on or before June 1 of the year in which examination is desired. Blanks for such application may be obtained by addressing the registrar of the college. All entrance credentials must be in the hands of the registrar before the applicant can matriculate.

B. Modes of Admission.

Students are admitted to the freshman class either upon certificate or upon examination. No *diploma* from a secondary school will be accepted.

Certificates. — Certificates will be received from those schools in New England which have been approved by the New England College Entrance Certificate Board. Principals of schools in New England who desire the certificate privilege should address the secretary of the Board, Professor Frank W. Nicolson, Wesleyan University, Middletown, Conn. Certificates from schools outside of New England will be received if those schools are on the approved list of the College Entrance Certificate Board of the section in which the school in question is located.

The credentials of the Board of Regents of the State of New York are accepted as satisfying the entrance requirements of this college when offered subject for subject.

Certificates must present not less than seven of the necessary fourteen credits in all. Those subjects lacking on certificate (except for the permitted number of conditions) must be made up at the time of the examinations for admission.

Blank forms for certification — sent to principals or school superintendents only — may be obtained on application to the registrar of the college.

Examinations. — The examination in each subject may be oral or written, or both. The standard required for passing an examination for admission is 65 per cent. Conditions to the amount of two units will be allowed.[1]

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[1] *Entrance with Condition in English.* — Under the rule permitting entrance conditions of not more than two units of the preparatory subjects, applicants may be admitted and upon examination, with a condition in English, provided that they show, upon examination, satisfactory preparation in work entitling them to a ranking of 60 or higher.

Students so admitted, must, to remove the condition, pass an examination covering the regular three-units requirement.

Places of Examination. — Examinations for admission to the college are held as follows: —

In June of each year: in Amherst in the building of the Department of Physics, Massachusetts Agricultural College; in Boston, in the College of Liberal Arts of Boston University, Boylston Street, corner of Exeter; in Worcester, in Horticultural Hall.

In September, examinations will be held in Amherst only.

Schedule for Entrance Examinations, June 18–20, inclusive, 1914. — The examinations in June will follow this schedule: —

First Day.

7.45 A.M.	Registration.[1]
8.00 A.M.	Plane geometry.
10.00 A.M.	Chemistry.
11.30 A.M.	Botany.
2.00 P.M.	Algebra.
3.30 P.M.	Physics.

Second Day.

8.00 A.M.	Required English.
11.00 A.M.	Solid geometry.
2.00 P.M.	History, required and elective.

Third Day.

8.00 A.M.	French, German, required and elective.
1.00 P.M.	Latin A and B and all one-half electives point, except those already noted.

Schedule for Entrance Examinations in September. — In September, 1914, the examinations will be given September 2–5, inclusive, and will follow the order indicated below: —

First Day.

1.00 P.M.	Registration.
1.15–5.00 P.M.	Greek A and B.

Second Day.

8.00 A.M.	Plane geometry.
10.00 A.M.	Chemistry.
11.30 A.M.	Botany.
2.00 P.M.	Algebra.
3.30 P.M.	Physics.
4.30 P.M.	Elective English.

Third Day.

8.00 A.M.	Required English.
11.00 A.M.	Solid geometry, agriculture.
2.00 P.M.	History, required and elective.

Fourth Day.

8.00 A.M.	French, German, required and elective.
1.00 P.M.	Latin A and B and all one-half credit electives, except those already noted.

C. Requirements for Admission.

The requirements for admission are based on the completion of a four-years' course in a high school, or its equivalent, and are stated in terms of units. The term unit means the equivalent of four or five recitations a week for a school year. **Neither more nor less credit will be given in any sub-**

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[1] Candidates who have no examination at the time set for registration may register at the time of their first examination should they so desire.

ject than is indicated in the table below. Fourteen units must be offered for admission. In the list given below, *every subject in black-faced type is absolutely required and no substitution is allowed.* The subjects so typed total eight and one-half units. In addition to these points five and one-half more units must be chosen from the subjects printed in light-faced type.

Agriculture,[1]	½ or 1
Botany,[2]	½ or 1
Chemistry,[2]	1
Algebra,	1½
Plane geometry,	1
Solid geometry,	½
Trigonometry,	½
Physics,[2]	1
Geology,[2]	½
Physiography,	½
Physiology,	½
Zoölogy,[2]	½
History[3] (Ancient; Medieval and Modern; English; General; United States and Civics), *any one,*	1[4]
English,	3
English (elective),[1]	1
Modern Language (elementary French or elementary German),	2
Elementary French,[5]	2
Elementary German,[5]	2
Intermediate French,	1
Advanced French,	1
Intermediate German,	1
Advanced German,	1
Greek A,[1]	2
Greek B,[1]	2
Latin A,	2
Latin B,	2
Commercial geography,[6]	½
Drawing,[6]	½
Manual training,[6]	½ or 1

PRESENTATION OF NOTE-BOOKS. — The keeping of a note-book is required as part of the preparation in those subjects indicated (see note 2, page 25).

Candidates presenting themselves for examination in such subjects must present at the same time the required note-book, properly certified by the principal. Candidates presenting such subjects on certificate should not present note-books; but their certificates must state that note-books have been satisfactorily completed.

D. Statement of Preparation required for Admission.

In some cases the requirements of the College Entrance Examination Board are here mentioned. A pamphlet containing detailed explanation of these requirements can be had of the Board for 10 cents. Address substation 84, New York City.

Agriculture. — Owing to the wide divergence of the methods of teaching agriculture in the public schools, the student will be required to bring a statement from the principal of the amount and kinds of work accomplished and

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[1] Examination in September only.

[2] Note-book required as part of preparation will be credited as part of the examination.

[3] One must be offered for the required point, one, two or three others may be offered for elective points.

[4] For each offered.

[5] May be offered as elective if not offered to satisfy *required* points.

[6] On certificate only, no examination given.

of the text-books used. The examination will be based somewhat upon this information; but it will call for not less than one-half year of creditable work of high school grade. **The examination in agriculture will be given in September only.**

Botany. — For one unit of credit in botany, the work outlined in the statement of requirements issued by the College Entrance Examination Board, or its equivalent, will be accepted. This work should occupy one school year and include laboratory and supplementary text-book study. For one-half unit of credit, work that covers the same ground but occupies half the time required for a full unit of credit will be accepted. These requirements are met by such texts as Steven's "Introduction to Botany" and Bergen and Davis's "Principles of Botany." A note-book containing neat, accurate drawings and descriptive records forms part of the requirement for either the half-unit or the one-unit credit, and this note-book must be presented by all applicants for admission upon examination in this subject. The careful preparation of an herbarium is recommended to all prospective students of this college, although the herbarium is not required.

Chemistry. — The entrance examination in chemistry will cover the work outlined by the College Entrance Examination Board as preparatory for college entrance. In general, this consists of a year of high school chemistry from such text-books as Newell's "Descriptive Chemistry" or Remsen's "Elements of Chemistry," with laboratory work on the general properties of the common elements, some of the experiments being quantitative. The keeping of a note-book is required.

Mathematics. — (*a*) *Required.* — Algebra: The four fundamental operations for rational algebraic expressions; factoring, determination of highest common factor and lowest common multiple by factoring; fractions, including complex fractions; ratio and proportion; linear equations, both numerical and literal, containing one or more unknown quantities; problems depending on linear equations; radicals, including the extraction of the square root of polynomials and numbers; exponents, including the fractional and negative; quadratic equations, both numerical and literal; simple cases of equations with one or more unknown quantities that can be solved by the methods of linear or quadratic equations; problems depending upon quadratic equations; the binomial theorem for positive integral exponents, the formulas for the nth term and the sum of the terms of arithmetic and geometric progressions, with applications.

Plane Geometry: The usual theorems and constructions of good text-books, including the general properties of plane rectilinear figures; the circle and the measurement of angles; similar polygons; areas; regular polygons and the measurement of the circle; the solution of numerous original exercises, including loci problems; applications to the mensuration of lines and plane surfaces.

(*b*) *Elective.* — Solid Geometry: The usual theorems and constructions of good text-books, including the relations of planes and lines in space; the properties and measurement of prisms, pyramids, cylinders and cones; the sphere and spherical triangle; the solution of numerous original exercises, including loci problems; applications to the mensuration of surfaces and solids.

Plane Trigonometry: A knowledge of the definitions and relations of trigonometric functions and of circular measurements and angles; proofs of the

principal formulas and the application of these formulas to the transformation of the trigonometric functions; solution of trigonometric equations, the theory and use of logarithms, and the solution of right and oblique triangles.

PHYSICS. — To satisfy the entrance requirement in physics, the equivalent of at least one unit of work is required. This work should consist of both class-room work and laboratory practice. The work covered in the class-room should be equal to that outlined in Hall & Bergen's "Text-book of Physics" or Millikan & Gale; the laboratory work should represent at least thirty-five experiments involving careful measurements, with accurate recording of each in laboratory note-book. This note-book, certified by the instructor in the subject, must be submitted by each candidate presenting himself for examination in physics; credit for passing the subject will be given on laboratory notes and on the examination paper submitted. Candidates entering on certificate will not be required to present note-books, but the principal's certification must cover laboratory as well as class-room work.

PHYSIOLOGY. — Hough & Sedgwick's "The Human Mechanism;" Martin's "The Human Body: Briefer Course."

ZOÖLOGY, PHYSIOGRAPHY, GEOLOGY. — The following suggestions are made concerning preparation for admission in the subjects named above: —

For physiography, Davis's "Elementary Physical Geography;" Gilbert & Brigham's "Introduction to Physical Geography." For zoölogy, text-books entitled "Animals" or "Animal Studies," by Jordan, Kellogg and Heath; Linville & Kelley's "A Text-book in General Zoölogy." For geology, A. P. Brigham's "A Text-book of Geology" or Tarr's "Elementary Geology."

Applicants for examination in zoölogy are *required* to present certified laboratory note-books; applicants for examination in the other subjects are *advised* to present note-books, if laboratory work has been done. Good note-books may be given credit for entrance. Examination in these subjects will be general, in recognition of the different methods of conducting courses; but students will be examined on the basis of the most thorough secondary school courses.

HISTORY. — The required unit must be offered in either ancient history, medieval and modern history, English history, general history, or United States history and civics. Either one, two or three elective units in any of the historical subjects here named may be offered, provided that such units may not be offered in the same subject in which the required unit has been offered.

Preparation in history will be satisfactory if made in accordance with the recommendations of the committee of seven of the American Historical Association, as outlined by the College Entrance Examination Board. The examination will require comparisons and the use of judgment by the candidate rather than the mere use of memory, and it will presuppose the use of good text-books, collateral reading and practice in written work. Geographical knowledge may be tested by requiring the location of places and movements on outline maps.

To indicate in a general way the character of the text-book work expected, the texts of the following authors are suggested: Botsford, Morey or Myers, in ancient history (to 814 A.D.); Adams, West or Myers, in medieval history; Montgomery, Larned or Cheyney, in English history; Myers or Fisher, in general history; Fiske, together with MacLaughlin or Montgomery, in United States history and civics.

ENGLISH. — For 1914: —

English Grammar and Composition. — Command of correct and clear English (spoken or written) requires instruction in grammar and composition. English grammar should ordinarily be reviewed in the secondary school; and correct spelling and grammatical accuracy should be rigorously exacted in connection with all written work during the four years. The principles of English composition governing punctuation, the use of words, paragraphs, and the different kinds of whole composition, including letter writing, should be thoroughly mastered; and practice in composition, oral as well as written, should extend throughout the secondary school period. Written exercises may well comprise narration, description and easy exposition and argument based upon simple outlines. It is advisable that subjects for this work be taken from the student's personal experience, general knowledge and studies other than English, as well as from his reading in literature. Finally, special instruction in language and composition should be accompanied by concerted effort of teachers in all branches to cultivate in the student the habit of using good English in his recitations and various exercises, whether oral or written.

Literature. — Ability to read with accuracy, intelligence and appreciation is sought through study of books included in two lists, headed respectively "Reading" and "Study," from which may be framed a progressive course in literature covering four years. In connection with both lists the student should be trained in reading aloud, and encouraged to commit to memory some of the more notable passages, both in verse and in prose. As an aid to literary appreciation, he is further advised to acquaint himself with the most important facts in the lives of the authors whose works he reads, and with their place in literary history.

(*a*) Reading: The aim of this course is to foster in the student the habit of intelligent reading, and to develop a taste for good literature by giving him a first-hand knowledge of some of its best specimens. He should read the books carefully, but his attention should not be so fixed upon details that he fails to appreciate the main purpose and charm of what he reads.

With a view to large freedom of choice, the books provided for reading are arranged in the following groups, from which at least ten units (each unit being set off by semicolons) are to be selected, two from each group: —

I. The "Old Testament," comprising at least the chief narrative episodes in Genesis, Exodus, Joshua, Judges, Samuel, Kings and Daniel, together with the books of Ruth and Esther; the "Odyssey," with the omission, if desired, of books I., II., III., IV., V., XV., XVI., XVII.; the "Iliad," with the omission, if desired, of books XI., XIII., XIV., XV., XVII., XXI.; Virgil's "Æneid." The "Odyssey," "Iliad" and "Æneid" should be read in English translations of recognized literary excellence.

For any unit of group I. a unit from any other group may be substituted.

II. Shakspere's "Merchant of Venice;" "Midsummer Night's Dream;" "As You Like It;" "Twelfth Night;" "Henry the Fifth;" "Julius Cæsar."

III. Defoe's "Robinson Crusoe," Part I.; Goldsmith's "Vicar of Wakefield;" either Scott's "Ivanhoe" or "Quentin Durward;" Hawthorne's "House of the Seven Gables;" either Dicken's "David Copperfield" or "A Tale of Two Cities;" Thackeray's "Henry Esmond;" Mrs. Gaskell's "Cranford;" George Eliot's "Silas Marner;" Stevenson's "Treasure Island."

IV. Bunyan's "Pilgrim's Progress," Part I.; "The Sir Roger de Coverley Papers" in "The Spectator;" Franklin's "Autobiography" (condensed); Irving's "Sketch Book," Macaulay's "Essays on Lord Clive" and "Warren Hastings;" Thackeray's "English Humourists;" selections from Lincoln, including at least the two inaugurals, the speeches in Independence Hall and at Gettysburg, the last public address and the letter to Horace Greeley, along with a brief memoir or estimate; Parkman's "Oregon Trail;" either Thoreau's "Walden," or Huxley's "Autobiography" and selections from "Lay Sermons," including the addresses on "Improving Natural Knowledge," "A Liberal Education" and "A Piece of Chalk;" Stevenson's "Inland Voyage" and "Travels with a Donkey."

V. Palgrave's "Golden Treasury" (first series), books II. and III., with especial attention to Dryden, Collins, Gray, Cowper and Burns; Gray's "Elegy in a Country Churchyard" and Goldsmith's "Deserted Village;" Coleridge's "Ancient Mariner" and Lowell's "Vision of Sir Launfal;" Scott's "Lady of the Lake;" Byron's "Childe Harold," Canto IV., and "Prisoner of Chillon;" Palgrave's "Golden Treasury" (first series), book IV., with especial attention to Wordsworth, Keats and Shelley; Poe's "Raven," Longfellow's "Courtship of Miles Standish," and Whittier's "Snow Bound;" Macaulay's "Lays of Ancient Rome" and Arnold's "Sohrab and Rustum;" Tennyson's "Gareth and Lynette," "Lancelot and Elaine" and "The Passing of Arthur;" Browning's "Cavalier Tunes," "The Lost Leader," "How They Brought the Good News from Ghent to Aix," "Home Thoughts from Abroad," "Home Thoughts from the Sea," "Incident of the French Camp," "Hervé Riel," "Pheidippides," "My Last Duchess," "Up at a Villa — Down in the City."

(*b*) Study: This part of the requirement is intended as a natural and logical continuation of the student's earlier reading, with greater stress laid upon form and style, the exact meaning of words and phrases, and the understanding of allusions. For this close reading are provided a play, a group of poems, an oration and an essay, as follows: —

Shakspere's "Macbeth;" Milton's "L'Allegro," "Il Penseroso" and "Comus;" either Burke's "Speech on Conciliation with America," or both Washington's "Farewell Address" and Webster's "First Bunker Hill Oration;" either Macaulay's "Life of Johnson," or Carlyle's "Essay on Burns."

Examination. — However accurate in subject-matter, no paper will be deemed satisfactory if seriously defective in punctuation, spelling or other essentials of good usage.

The examination will be divided into two parts, one of which may be taken as a preliminary, and the other as a final.

The first part of the examination will be based upon ten units chosen, in accordance with the plan described earlier, from the lists headed reading; and it may include also questions upon grammar and the simpler principles of rhetoric, and short compositions upon topics drawn from the student's general knowledge or experience. On the books prescribed for reading, the form of the examination will usually be the writing of short paragraphs on several topics which the candidate may choose out of a considerable number. These topics will involve such knowledge and appreciation of plot, character-development, and other qualities of style and treatment, as may be fairly expected of boys and girls. In grammar and rhetoric, the candidate may

be asked specific questions upon the practical essentials of these studies, such as the relation of the various parts of a sentence to one another, the construction of individual words in a sentence of reasonable difficulty, and those good usages of modern English which one should know in distinction from current errors.

The second part of the examination will include composition and those books comprised in the list headed study. The test in composition will consist of one essay or more, developing a theme through several paragraphs; the subjects will be drawn from the books prescribed for study, from the candidate's other studies and from his personal knowledge and experiences quite apart from reading. For this purpose the examiner will provide several subjects from which the candidate may make his own selections. The test on the books prescribed for study will consist of questions upon their content, form and structure, and upon the meaning of such words, phrases and allusions as may be necessary to an understanding of the works and an appreciation of their salient qualities of style. General questions may also be asked concerning the lives of the authors, their other works, and the periods of literary history to which they belong.

English, Elective.[1] — To secure a fourth entrance credit in English, the applicant should do (*a*) the full equivalent of three years' work (required English), and also (*b*) the full equivalent of a fourth year's work. Applicants not certified with a fourth entrance credit will be examined, provided that the applicant, on or before June 1, notify the Department of English of his intention to take the examination, and supply thereafter the information needed by the department to prepare the examination questions. The information blanks will be forwarded by the Department of English upon receipt of the notice.

Subjects accepted. — The applicant may offer (*a*) any one of the subjects stated hereunder, or (*b*) any two of these subjects in combination.

(*a*) History of American literature.
(*b*) History of English literature (or lives of the great authors).
(*c*) Classics *other than those read to meet the three-credit requirement.*
(*d*) Advanced composition.
(*e*) History of the English language.
(*f*) Advanced high school grammar.

Advanced Standing in College. — Whether advanced standing shall be given applicants entering with a fourth credit in English will be determined by consideration of each case individually. Much weight is given to the ability of the student to express himself correctly and clearly, to think clearly, and to grasp the meaning of printed language. A special examination will be given in the opening week of college, notice of which will be posted on the English bulletin board, for freshmen who wish to apply for advanced standing.

Presentation of Note-books and Themes. — Applicants for examination, either for fourth-unit credit or for advanced standing, are advised to present the note-books, themes, etc., prepared by them in the preparatory school, as an aid toward determining their proficiency.

English. — For 1915–19 inclusive: —

The National Conference on Uniform Entrance Requirements in English voted that the following be the requirements for the years 1915, 1916, 1917, 1918 and 1919.

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[1] **Examination given in September only.**

This supersedes the previously announced requirement for 1915.

The study of English in school has two main objects: (1) command of correct and clear English, spoken and written; (2) ability to read with accuracy, intelligence and appreciation.

Grammar and Composition. — The first object requires instruction in grammar and composition. English grammar should ordinarily be reviewed in the secondary school; and correct spelling and grammatical accuracy should be rigorously exacted in connection with all written work during the four years. The principles of English composition governing punctuation, the use of words, sentences and paragraphs should be thoroughly mastered; and practice in composition, oral as well as written, should extend throughout the secondary school period. Written exercises may well comprise letter-writing, narration, description and easy exposition and argument. It is advisable that subjects for this work be taken from the student's personal experience, general knowledge and studies other than English, as well as from his reading in literature. Finally, special instruction in language and composition should be accompanied by concerted effort of teachers in all branches to cultivate in the student the habit of using good English in his recitations and various exercises, whether oral or written.

Literature. — The second object is sought by means of two lists of books, headed, respectively, "Reading" and "Study," from which may be framed a progressive course in literature covering four years. In connection with both lists the student should be trained in reading aloud and encouraged to commit to memory some of the more notable passages both in verse and in prose. As an aid to literary appreciation, he is further advised to acquaint himself with the most important facts in the lives of the authors whose works he reads and with their place in literary history.

A. Reading. — The aim of this course is to foster in the student the habit of intelligent reading and to develop a taste for good literature by giving him a first-hand knowledge of some of its best specimens. He should read the books carefully, but his attention should not be so fixed upon details that he fails to appreciate the main purpose and charm of what he reads.

With a view to large freedom of choice, the books provided for reading are arranged in the following groups, from each of which at least two selections are to be made, except as otherwise provided under Group I.: —

Group I. Classics in Translation: The "Old Testament," comprising at least the chief narrative episodes in Genesis, Exodus, Joshua, Judges, Samuel, Kings and Daniel, together with the books of Ruth and Esther; the "Odyssey," with the omission, if desired, of books I., II., III., IV., V., XV., XVI., XVII.; the "Iliad," with the omission, if desired, of books XI., XIII., XIV., XV., XVII., XXI.; the "Æneid." The "Odyssey," "Iliad" and "Æneid" should be read in English translations of recognized literary excellence.

For any selection from group I. a selection from any other group may be substituted.

Group II. Shakspere: "Midsummer Night's Dream;" "Merchant of Venice;" "As You Like It;" "Twelfth Night;" "The Tempest;" "Romeo and Juliet;" "King John;" "Richard II.;" "Richard III.;" "Henry V.;" "Coriolanus;" "Julius Cæsar;"[1] "Macbeth;"[1] "Hamlet."[1]

Group III. Prose Fiction: Malory's "Morte d'Arthur" (about 100 pages); Bunyan's "Pilgrim's Progress," Part I.; Swift's "Gulliver's Travels" (voy-

[1] If not chosen for study under B.

ages to Lilliput and to Brobdingnag); Defoe's "Robinson Crusoe," Part I.; Goldsmith's "Vicar of Wakefield;" Frances Burney's "Evelina;" Scott's novels, any *one;* Jane Austen's novels, any *one;* Maria Edgeworth's "Castle Rackrent" or "The Absentee;" Dickens's novels, any *one;* Thackeray's novels, any *one;* George Eliot's novels, any *one;* Mrs. Gaskell's "Cranford;" Kingsley's "Westward Ho!" or "Hereward the Wake;" Reade's "The Cloister and the Hearth;" Blackmore's "Lorna Doone;" Hughes's "Tom Brown's School Days;" Stevenson's "Treasure Island" or "Kidnapped" or "Master of Ballantrae;" Cooper's novels, any *one;* Poe's "Selected Tales;" Hawthorne's "The House of the Seven Gables" or "Twice Told Tales" or "Mosses from an Old Manse;" a collection of short stories by various standard writers.

Group IV. Essays, Biography, etc.: Addison and Steele's "The Sir Roger de Coverley Papers" or selections from the "Tatler" and "Spectator" (about 200 pages); selections from Boswell's "Life of Johnson" (about 200 pages); Franklin's "Autobiography;" selections from Irving's "Sketch Book" (about 200 pages) or "Life of Goldsmith;" Southey's "Life of Nelson;" selections from Lamb's "Essays of Elia" (about 100 pages); selections from Lockhart's "Life of Scott" (about 200 pages); Thackeray's "Lectures on Swift, Addison and Steele in the English Humorists;" Macaulay: any one of the following essays: "Lord Clive," "Warren Hastings," "Milton," "Addison," "Goldsmith," "Frederic the Great," "Madame d'Arblay;" selections from Trevelyan's "Life of Macaulay" (about 200 pages); Ruskin's "Sesame and Lilies" or "Selections" (about 150 pages); Dana's "Two Years before the Mast;" Lincoln's "Selections," including at least the two inaugurals, the speeches in Independence Hall and at Gettysburg, the last public address, the letter to Horace Greeley, together with a brief memoir or estimate of Lincoln; Parkman's "The Oregon Trail;" Thoreau's "Walden;" Lowell's "Selected Essays" (about 150 pages); Holmes's "The Autocrat of the Breakfast Table;" Stevenson's "An Inland Voyage" and "Travels with a Donkey;" Huxley's "Autobiography" and selections from "Lay Sermons," including the addresses on "Improving Natural Knowledge," "A Liberal Education" and "A Piece of Chalk;" a collection of "Essays" by Bacon, Lamb, De Quincey, Hazlitt, Emerson and later writers; a collection of "Letters" by various standard writers.

Group V. Poetry: Palgrave's "Golden Treasury" (first series), books II. and III., with special attention to Dryden, Collins, Gray, Cowper and Burns; Palgrave's "Golden Treasury" (first series), book IV., with special attention to Wordsworth, Keats and Shelley (if not chosen for study under B); Goldsmith's "The Traveller" and "The Deserted Village;" Pope's "The Rape of the Lock;" a collection of English and Scottish ballads, as, for example, some "Robin Hood" ballads, "The Battle of Otterburn," "King Estmere," "Young Beichan," "Bewick and Grahame," "Sir Patrick Spens" and a selection from later ballads; Coleridge's "The Ancient Mariner," "Christabel" and "Kubla Khan;" Byron's "Childe Harold," Canto III. or IV., and "The Prisoner of Chillon;" Scott's "The Lady of the Lake," or "Marmion;" Macaulay's "The Lays of Ancient Rome," "The Battle of Naseby," "The Armada," "Ivry;" Tennyson's "The Princess" or "Gareth and Lynette," "Lancelot and Elaine" and "The Passing of Arthur;" Browning's "Cavalier Tunes," "The Lost Leader," "How They Brought the Good News from Ghent to Aix," "Home Thoughts from Abroad," "Home Thoughts from the Sea," "Incident of the French Camp," "Hervé Riel," "Pheidippides," "My Last

Duchess," "Up at a Villa — Down in the City," "The Italian in England," "The Patriot," "The Pied Piper," "De Gustibus," "Instans Tyrannus;" Arnold's "Sohrab and Rustum" and "The Forsaken Merman;" selections from American poetry, with special attention to Poe, Lowell, Longfellow and Whittier.

B. Study. — This part of the requirement is intended as a natural and logical continuation of the student's earlier reading, with greater stress laid upon form and style, the exact meaning of words and phrases, and the understanding of allusions. The books provided for study are arranged in four groups, from each of which one selection is to be made.

Group I. Drama: Shakspere's "Julius Cæsar," "Macbeth," "Hamlet."

Group II. Poetry: Milton's "L'Allegro," "Il Penseroso" and either "Comus" or "Lycidas;" Tennyson's "The Coming of Arthur," "The Holy Grail" and "The Passing of Arthur;" the selections from Wordsworth, Keats and Shelley in Book IV. of Palgrave's "Golden Treasury" (first series).

Group III. Oratory: Burke's "Speech on Conciliation with America;" Macaulay's "Speech on Copyright" and Lincoln's "Speech at Cooper Union;" Washington's "Farewell Address" and Webster's "First Bunker Hill Oration."

Group IV. Essays: Carlyle's "Essay on Burns," with a selection from Burns's "Poems;" Macaulay's "Life of Johnson;" Emerson's "Essay on Manners."

Examination. — However accurate in subject-matter, no paper will be considered satisfactory if seriously defective in punctuation, spelling or other essentials of good usage.

The examination will be divided into two parts, one of which will be on grammar and composition, and the other on literature.

In grammar and composition, the candidate may be asked specific questions upon the practical essentials of these studies, such as the relation of the various parts of a sentence to one another, the construction of individual words in a sentence of reasonable difficulty, and those good usages of modern English which one should know in distinction from current errors. The main test in composition will consist of one or more essays, developing a theme through several paragraphs; the subjects will be drawn from the books read, from the candidate's other studies and from his personal knowledge and experience quite apart from reading. For this purpose the examiner will provide several subjects, perhaps eight or ten, from which the candidate may make his own selections. He will not be expected to write more than four hundred words per hour.

The examination in literature will include: —

(*a*) General questions designed to test such a knowledge and appreciation of literature as may be gained by fulfilling the requirements defined under "A, Reading," above. The candidate will be required to submit a list of the books read in preparation for the examination, certified by the principal of the school in which he was prepared; but this list will not be made the basis of detailed questions.

(*b*) A test on the books prescribed for study, which will consist of questions upon their content, form and structure, and upon the meaning of such words, phrases and allusions as may be necessary to an understanding of the works and an appreciation of their salient qualities of style. General questions may also be asked concerning the lives of the authors, their works and the periods of literary history to which they belong.

The Massachusetts Agricultural College calls attention to the following recommendations of the national conference, which agree with its policy: —

1. That colleges so desiring may set an examination requiring no prescribed books, but testing the same general kind of preparation as that indicated in the foregoing requirements.

2. That individual colleges take such steps as may be found necessary to ascertain whether candidates for entrance possess an adequate equipment in oral English.

As rapidly as seems expedient the college will proceed in accordance with these recommendations. Schools wishing to present candidates prepared in conformity to the intent of the recommendations will have the co-operation of the college.

French. — The necessary preparation for this examination is stated in the description of the two-year course in elementary French recommended by the Modern Language Association, contained in the definition of requirements of the College Entrance Examination Board.

Third and fourth year French (elective subjects for admission). — For a third credit unit in French as an elective subject for entrance, the work heretofore described by the College Entrance Examination Board as "intermediate" is expected. For a fourth credit unit, the work described as "advanced" is expected.

German. — The entrance requirements in German conform to those of the College Entrance Examination Board for elementary German (the standard two-year requirements).

Third and fourth year German (elective subjects for admission). — For a third credit unit in German as an elective subject for entrance, when required units have been offered in German, the work heretofore described by the College Entrance Examination Board as "intermediate" is expected. For a fourth credit unit, the work described as "advanced" is expected.

Greek. — Greek will receive credit as an elective requirement upon either examination or certification, as follows (**examination in September only**): —

A. Two credit units will be allowed if satisfactory proficiency is shown (including grammar) in (*a*) the translation of a passage or passages taken from the first four books of Xenophon's "Anabasis," and (*b*) the translation of passages of Attic prose at sight.

B. Three credit units will be allowed if, in addition to the above, satisfactory proficiency be shown in (*a*) the translation of a passage or passages from the first six books of Homer's "Iliad," and (*b*) translation of passages of Homer's "Iliad" at sight, with questions on the form and constructions of the passages.

Latin. — Latin will receive credit as an elective requirement upon either examination or certification, as follows: —

A. Two credit units will be allowed if satisfactory proficiency is shown (including grammar) in (*a*) the translation of a passage or passages taken from Cæsar's "Gallic War," covering at least four books, and (*b*) the translation of passages of Latin prose at sight.

B. Three credit units will be allowed if, in addition to the above, satisfactory proficiency be shown in (*a*) the translation of a passage or passages selected from either books I. to VI. of Virgil's "Æneid," or six orations of Cicero, including those against Catiline; and (*b*) the translation into Latin prose of a passage of connected English narrative based on some portion of Cæsar's "Gallic War," books I. to IV.

Commercial Geography.[1] — Preparation should be made in a course equivalent to that laid down in Adams's "Commercial Geography," Trotter's "Geography of Commerce," or a similar work.

Drawing.[1] — Applicants may offer either freehand or mechanical drawing, or both. They must be able to make an accurate freehand sketch, in either outline or light and shade, of the appearance of a group of geometric solids, and have a sufficient knowledge of perspective to enable them to draw correctly a simple geometric model from memory; or, if they present mechanical drawing, they must have considerable working familiarity with drawing instruments, and be able to make an accurate inked working drawing, in orthographic projection, of some simple object. Emphasis is laid on facility in doing good freehand lettering. For a limitation of the work that may be presented see "Manual Training."

Manual Training.[1] — An entrance credit of one-half or one unit is allowed for manual training, on the presentation of a certificate from the principal of the school showing the scope and character of the applicant's work. The preparation may include mechanical drawing, working in wood, metals, leather, etc. When mechanical drawing is presented as a part of the work in manual training, no other credit for drawing will be allowed. No examination is given in this subject; applicants must present certificates to secure credit.

E. Admission to Advanced Standing.

Candidates for admission to advanced standing, in addition to meeting the regular entrance requirements, must also pass examinations in those subjects already pursued by the class they desire to enter. To meet this requirement, a student transferring to this college from another college or university of recognized standing must present the following credentials: —

1. A letter of honorable dismissal from the institution with which he has been connected.
2. A statement or certificate of his entrance record.
3. A statement from the proper officer showing a complete record of his work while in attendance.
4. A marked catalogue showing the courses pursued.

These credentials should be presented to the registrar. Applications will be judged wholly on their merits and the college may prescribe additional tests before accepting applicants or determining the standing to be granted them.

F. Other Information about Entrance.

1. The privileges of the college may be withdrawn from any student at any time if such action is deemed advisable. (It is immaterial whether the pupil has entered by certificate or by examination.)

2. The examination in each subject may be either oral or written, or both. The standard required for passing an entrance examination is 65 per cent.

3. Candidates must receive credit for twelve units out of the total number required for entrance, and will be conditioned in those subjects not passed. No candidate deficient in both algebra and plane geometry will be admitted.

4. Examinations for the removal of entrance conditions will be held as follows: (1) First entrance condition examination, in the week following

[1] On certificate only.

the Thanksgiving recess. (2) Second entrance condition examination, in the sixteenth week of the first semester.

5. Credits for entrance requirements, whether gained by certificate or by examination, will hold good for one year.

6. Examinations in part of the subjects required for entrance may be taken one year before entering college.

7. For information concerning expenses, scholarships, etc., see "General Information."

8. For information concerning admission to short courses see "Short Courses."

G. Unclassified Students.

All requests for information concerning admission of unclassified students should be addressed to Professor W. P. B. Lockwood, chairman of committee on unclassified students.

Students not candidates for a degree (unclassified students) are admitted under the following provisions: —

1. No entrance examination is required, but applicants must bring certificates showing that they have finished a four-years' high school course or its equivalent, and furnish satisfactory testimonials as to moral character.

2. No applicant under twenty-one years of age will be admitted as an unclassified student.

3. Each unclassified student must take from the regular courses a minimum of twelve credit hours a week.

4. In order to be admitted to any course, an unclassified student must have had all prerequisite subjects for that course.

5. Every unclassified student must do all the work of the courses elected, and take all examinations therein. In order to pass such courses he must attain a grade of at least 75 per cent. An unclassified student who passes in less than two-thirds of his work will be dropped from college.

6. All unclassified students are subject to the supervision of a special committee.

7. Any unclassified student may be dropped from college at any time if his presence in any class is undesirable or his work is unsatisfactory; and no unclassified student will be allowed to remain in college more than four semesters without the special permission of the faculty.

8. Unclassified students are subject to the regulations applying to classified students.

9. No student of this or any other institution who has not done efficient work therein shall be permitted to register as an unclassified student.

10. No unclassified student shall be allowed to participate in any intercollegiate contests.

Courses of Instruction.

A. TABLE OF FRESHMAN AND SOPHOMORE SUBJECTS.

The figures indicate the number of credit hours a week. For details, see the descriptions of courses.

Freshman Year.

First Semester.

Subjects. All work required.	Hours per Week.
Chemistry,	3
Algebra,	3
Solid Geometry,[1]	2
English,	4
Public Speaking (at option of instructor),	1
French or German,[2]	4
Drill,	1
Hygiene,	1
College Life (attendance without credit).	
	18 or 19

Second Semester.

Subjects. All work required.	Hours per Week.
Animal Husbandry,	2
Chemistry,	3
Trigonometry,	3
Algebra,	2
English,	4
Public Speaking (if not taken in semester one),	1
French or German,	4
Drill,	1
Physical Education,	1
	20 or 21

Sophomore Year.

First Semester.

Subjects. All work required.	Hours per Week.
Agronomy,	3
Physics,	5
Zoölogy,	3
English,	2
French or German,	3
Tactics,	1
Drill,	1
Chemistry or Animal Husbandry (elective),	3
	21

[1] To be taken in course when not offered for entrance.

[2] Students who have had three or four years of one language in the preparatory school will elect the other language. Students who have had two years of one language may have their choice of election. Whichever language they so elect must be continued to the end of the first semester of the sophomore year. Eleven college credits are required in this language.

Second Semester.

All courses under "Required," with any two of those under "Elective."

Subjects. Required.	Hours per Week.
Elementary Horticulture,	2
Botany,	4
English,	2
Agricultural Industry,	3
Drill,	1
Tactics,	1
Physical Education,	1
	14

Elective.

French or German, Geology, Physics, Chemistry, Surveying,	Each 3 hours. Any two,	6
		20

B. MAJORS: JUNIOR AND SENIOR YEARS.

General Statement.

A major consists of 30 hours of correlated work, to be arranged by the student and an instructor called the adviser.

The list of courses found under each major on subsequent pages should not be considered as necessarily a rigid program to be followed. The heads of departments have suggested this series of courses as the best for the average man majoring in their departments. Advisers may, however, make modifications to suit the particular needs of the student, provided these modifications conform precisely to the class schedule as published for the year.

Rules.

Rule 1. *Election.* — Each student, in the second semester of his sophomore year, shall elect a major subject from the list of majors given below; and this major shall consist of 30 credit hours of correlated work.

Rule 2. *Minimum Credits.* — The minimum number of credits for the junior and senior years shall be 65, inclusive of Military Drill and Physical Education.

Rule 3. *Maximum Credits.* — The maximum number of credits for any semester of the junior or senior year shall be 21.

Rule 4. *Humanities and Rural Social Science.* — A minimum of 15 credit hours in the Divisions of the Humanities and Rural Social Science will be required of all students during their junior and senior years, with the following restriction: that a minimum of 3 credit hours will be required in each of the Divisions.

Rule 5. *Advisers.* — The work of each junior and senior will be under the immediate supervision of an instructor designated as major adviser. Ordinarily, the major adviser will be the head of the department in which the student intends to elect his major. Each student should consult with the adviser as soon as possible. The adviser has full authority to prescribe the student's work up to 30 hours. It is understood, however, that so far as practicable the individual needs of the student will be recognized. It is also hoped and expected that students will be disposed to seek the counsel of the adviser with respect to the remaining courses required for graduation.

Rule 6. *Free Electives.* — Each student is required to take 30 hours in his major and also 15 hours in the Divisions of the Humanities and Rural Social Science, making a total of 45 hours. He is allowed free choice of courses to complete his required hours, this remainder amounting to 15 hours minimum, or 35 hours maximum for the two years.

Rule 7. *Registration.* — No upper classman shall register until his major course of study is approved by his adviser.

(1) Course cards for recording the election of majors will be issued from the registrar's office on June 1.

(2) This card must be submitted by each student to his major adviser, who will lay out the course for the year and countersign the card.

(3) Each course card must be filled out, giving the name of student, his college address, the name of parent or guardian, and the student's home address. When the major courses have been entered on this card, and the hours of free elections added by the student, the card must be returned to the registrar not later than June 10.

Rule 8. *Changes.* — Applications for changes may be made to the dean in writing at any time; when approved by him and by the committee on scholarship, they become operative at the beginning of the semester following, provided that no change in the selection of a major may be made by any student after registration day of his senior year.

LIST OF MAJORS.

Agriculture.

Professor James A. Foord, Adviser.

Course.	Credit.
Agronomy 3,	3
Agronomy 6,	3
Animal Husbandry 3,	3
Animal Husbandry 5,	3
Animal Husbandry 9,	3
Dairying 1,	3
Dairying 2,	3
Farm Administration 3,	3
Farm Administration 4,	3
Microbiology 1 and 2,	5
	32

Chemistry 7 and 8, Veterinary Science 1, Microbiology 2, Pomology 1 and Animal Husbandry 6 are suggested as additional courses for the student fitting himself for general agriculture.

Agronomy.

Associate Professor Sidney B. Haskell, Adviser.

Course.	Credit.
Agronomy 3,	3
Agronomy 4,	3
Agronomy 5,	3
Agronomy 6,	3
Agronomy 8,	3
Animal Husbandry 9,	3
Farm Administration 4,	3
Chemistry 5,	5
Chemistry 6,	5
	31

Animal Husbandry.

Associate Professor J. Allan McLean, Adviser.

Course.	Credit.
Agronomy 3,	3
Veterinary Science 1, Veterinary Hygiene and Stable Sanitation,	3
Veterinary Science 2, General Veterinary Pathology (Materia Medica and Therapeutics),	3
Animal Husbandry 5,	3
Animal Husbandry 6,	1
Animal Husbandry 8,	2
Animal Husbandry 9,	3
Animal Husbandry 10,	3
Animal Husbandry 11,	2
Dairying 1,	3
Farm Administration 3,	3
Farm Administration 4,	3
	32

Dairying.

Professor William P. B. Lockwood, Adviser.

Course.	Credit.
Animal Husbandry 5,	3
Animal Husbandry 6,	1
Animal Husbandry 8,	2
Animal Husbandry 9,	3
Animal Husbandry 11,	2
Dairying 1,	3
Dairying 2,	3
Dairying 3,	3
Microbiology 11 and 12,	3
Farm Administration 3,	3
Farm Administration 4,	3
	29

Poultry Husbandry.

Professor John C. Graham, Adviser.

Course.	Credit.
Poultry Husbandry 1,	2
Poultry Husbandry 2,	2
Poultry Husbandry 3,	1
Poultry Husbandry 4,	1-3
Poultry Husbandry 5,	1
Poultry Husbandry 6,	3
Poultry Husbandry 7,	3
Poultry Husbandry 9,	3
Pomology 1,	3
Agronomy 3,	3
Animal Husbandry 5,	3
Animal Husbandry 9,	3
Veterinary Science 7,	3
	31-33

Floriculture.

Professor —— ——, Adviser.

Course.	Credit.
Floriculture 1,	4
Floriculture 2,	4
Floriculture 3,	3
Floriculture 4,	3
Horticulture 3,	3
Horticulture 4,	3
Entomology 1,	3
Market Gardening 2,	3
Botany 2,	4
	30

Note. — Horticulture 3 and 4 is a junior subject, but to balance the work for the two years it would be better for the floricultural students to take the course in the senior year.

Forestry.

Professor William D. Clark, Adviser.

Course.	Credit.
Forestry 3,	3
Forestry 4,	3
Forestry 5,	5
Forestry 6,	3
Entomology 5,	3
Landscape Gardening 1,	3
Horticulture 3,	3
Horticulture 4,	3
Botany 13,	4
	30

Students who propose to major in forestry should elect geology and surveying in sophomore year.

Landscape Gardening.

Professor Frank A. Waugh, Adviser.

Course.	Credit.
Landscape Gardening 1,	3
Landscape Gardening 2,	3
Landscape Gardening 3,	3
Landscape Gardening 4,	3
Landscape Gardening 5,	2
Landscape Gardening 6 or 10,	2
Landscape Gardening 7,	3
Landscape Gardening 8,	3
Drawing 1,	3
Drawing 2,	3
Horticulture 3,	3
	31

Courses for juniors *only:* Landscape Gardening 1 and 2, Drawing 1 and 2.
Courses for seniors and graduates *only:* Landscape Gardening 3, 4, 7 and 8.
Courses open to juniors and seniors, both if possible: Horticulture 3 and 4.
This grouping of subjects is offered only as an example. Other groupings may be approved by the adviser, but such other groupings must be subject to the class schedule.

Pomology.

Professor Fred C. Sears, Adviser.

Course.	Credit.
Pomology 1,	3
Pomology 2,	3
Pomology 3,	3
Pomology 4,	3
Pomology 6,	2
Botany 5,	2
Agronomy 5,	3
Entomology 1,	3
Entomology 2,	3
	25

Agricultural Chemistry.

Associate Professor Charles A. Peters, Adviser.

Course.	Credit.
Chemistry 5,	5
Chemistry 6,	5
Chemistry 9,	5
Chemistry 10,	5
Chemistry 11,	5
Chemistry 12, 14 or 16,	5
Chemistry 13,	3
Chemistry 15,	3
Chemistry 18,	2
	38

The majör will consist of 30 credit hours selected from this list. The student will be advised concerning other subjects suitable to be taken in connection with Chemistry.

Economic Entomology.

Professor Henry T. Fernald, Adviser.

Course.	Credit.
Entomology 1,	3
Entomology 2,	2
Entomology 3,	4
Entomology 4,	4
Entomology 5,	3
Entomology 8,	3
Botany 3,	4
Botany 4,	2
Zoölogy 3,	3
Zoölogy 4,	3
	31

A major in Economic Entomology does not necessarily include all the subjects given in this list, but may be varied to some extent, in accordance with the future plans of the student, other modifications being permissible.

Rural Social Science.

Dr. Alexander E. Cance, Associate Professor E. K. Eyerly, Advisers.

Course.	Credit.
Economics and Sociology 1,	3
Agricultural Economics 3,	3
Agricultural Economics 7,	3
Agricultural Economics 6 or 8,	3
Rural Sociology 2,	3
Rural Sociology 4,	1
Rural Sociology 5 or 7,	3
Rural Sociology 8,	3
Rural Sociology 10,	3
Rural Sociology 11,	3
Farm Administration 4,	3
	31

Microbiology.

Dr. Chas. E. Marshall, Adviser.

Course.	Credit.
Microbiology 1 and 2,	5
Microbiology 3 and 4,	5
Microbiology 5 and 6,	3
Microbiology 7 and 8,	3
Chemistry 3,	5
Chemistry 4,	5
Chemistry 5,	3
Chemistry 6,	3
	32

Courses 9 in Chemistry; 3, 4, 5 in Botany; 3, 4, 5, 6 in Zoölogy; 1, 3, 5, 6 in Veterinary Science, together with German and French, are suggested as collateral lines. Dairying 1 and Agronomy 5 are essential to a grasp of the larger problems involved in Microbiology as applied to Agriculture.

Plant Physiology and Pathology.

Professor George E. Stone, Adviser.

Course.	Credit.
Botany 3,	4
Botany 4,	2
Botany 10,	4 or 5
Botany 14,	4
Botany 11,	5
Chemistry 5,	5
Chemistry 6,	5
Entomology 1,	3
Entomology 2,	2
	34 or 35

Agricultural Education.

Professor William R. Hart, Adviser.

Course.	Credit.
Agricultural Education 1,	3
Agricultural Education 2,	3
Agricultural Education 3,	3
Agricultural Education 4,	3
Agronomy 3,	3
Dairying 5,	2
Farm Administration 3,	3
Poultry Husbandry 1,	2
Market Gardening 2, } Agronomy 5, }	3
Botany 5,	2
Pomology 1,	3
	30

Some substitutions of other technical courses for some of the technical courses above mentioned will be made to meet the needs of individual students.

Summary.

There are four preliminary steps which a student should take in arranging for his major work.

1. Select a major.
2. Confer with major adviser for arrangement of courses, the plan to be approved by adviser in accordance with Rule 5 previously stated.
3. Select courses covering the four semesters of the junior and senior years in such a way that a minimum of 15 credits will be taken in the two Divisions, the Humanities and Rural Social Science; the distribution of all but 3 of these credits may be decided by the student.
4. Choose other courses so that the total number of credits for any semester shall be not less than 16 nor more than 21. (See Rules 2 and 3.)

C. UNDERGRADUATE COURSES.

All courses given in the *first semester bear odd numbers;* all given in the *second semester bear even numbers.* Studies are pursued in courses, "course" implying the study given a subject within one semester, without regard to the total number of hours or to the number of credits. The special mention of certain courses as prerequisite to other courses does not imply that no courses but those so mentioned are "preliminary or preparatory" within the meaning of the Book of Rules.

DIVISION OF AGRICULTURE.

Professor Foord.

AGRONOMY.

Associate Professor Haskell, Dr. Brooks, Assistant Professor McDonald, Mr. Lund.

Required Course.

1. Soils and Fertilizers. — A study of the formation, classification and physical and chemical properties of soils. This is followed by study of methods of soil improvement and of maintenance of fertility, including the use of farm manures, commercial fertilizers and soil amendments. Prerequisites, Chemistry 1 and 2. Sophomores; 3 hours. Credit, 3.

Associate Professor Haskell and Assistant Professor McDonald.

Elective Courses.

3. Field and Forage Crops. — History, classification, cultivation, harvesting, commercial grading and valuation. The crops studied are the cereal grains, grasses, legumes, forage and root crops suitable to New England conditions. The work includes lecture, laboratory and field study of these various crops. Prerequisites, Agronomy 1 and Botany 2. For juniors primarily; 1 lecture and 2 laboratory periods. Credit, 3.

Assistant Professor McDonald.

4. Advanced Field Crops. — Commercial production of grain, hay and root crops. Lecture, laboratory, and field study of the purity, quality, and vitality of the seed of these crops and the handling, grading and judging of their products. The work offered will not be confined to New England conditions. Prerequisite, Agronomy 3. For juniors primarily; 2 lectures and 1 laboratory period. Credit 3. Assistant Professor McDonald.

5. Advanced Soils. — A field, laboratory and lecture course on soils, their nature, composition, physical qualities, improvement. Field work, as far as the season allows, consists of detailed soil surveys in different parts of the Connecticut valley; this followed by laboratory work on the physical properties of the soil collected, on the effect of fertilizers on the soil, and on the mixing of fertilizers. Prerequisite, Agronomy 1. For seniors primarily; 1 lecture period and 1 4-hour laboratory period weekly. Credit, 3.

Associate Professor Haskell.

6. Drainage and Irrigation. — A field and lecture course on soil improvement, by drainage and irrigation. As a thesis each man is required, after studying an area of wet or swampy land, to present plans and estimates for its reclamation. Prerequisites, Agronomy 1 and Mathematics 6. Juniors and seniors; 1 lecture period and 1 4-hour laboratory period weekly. Credit 3. Associate Professor Haskell.

8. Manures and Fertilizers. — An advanced course, giving a general discussion of the different theories which have been held relative to the functions and importance of manures and fertilizers, and leading up to the views at present accepted. Each of the important manures and fertilizers will be discussed, its origin and its chemical and physical characteristics being considered. Each material taken up will be studied in relation to its capacity to supply plant food and to its effects upon soil texture, moisture, temperature and flora. Considerable attention will be devoted to consideration of the experimental work which has been done, and which is now in progress, in manures and fertilizers. This course is intended for seniors only. Prerequisite, Agronomy 1; 3 lectures a week, with occasional seminars. Credit, 3.

Dr. Brooks.

ANIMAL HUSBANDRY.

Associate Professor McLean, Mr. Quaife.

Required Course.

2. Market Classes and Grades of Live Stock. — A study of the different market classes and grades of horses, cattle, sheep and swine. The purpose of this course is to familiarize beginners with the different classes of stock, and to give them a grounding in live stock judging. Text-book, Craig's "Live Stock Judging." Freshmen; 2 laboratory periods. Credit, 2.

Associate Professor McLean and Mr. Quaife.

Elective Courses.

3. Breeds and Types of Live Stock. — A course covering the origin, history, development and characteristics of the different breeds of horses, cattle, sheep and swine. Text-book, Plumb's "Breeds and Types of Farm Animals." Prerequisite, Animal Husbandry 2. Sophomores; 1 lecture and 2 laboratory periods. Credit, 3.

Associate Professor McLean and Mr. Quaife.

5. Principles of Breeding. — This course is designed to familiarize the student with the problems involved in animal and plant improvement; to acquaint him with the facts which are already established; to scrutinize prevailing theories; and to indicate the lines and methods of further work. Some of the subjects studied are: variations, their causes and heritability; De Vrie's theory of mutations; the inheritance of acquired characters; the pure line; Mendelian law; the making of new types; the determination of sex; applications to human heredity. A few periods at the end of the course are devoted especially to the application of principles in live stock improvement. Text, "Genetics," by Herbert E. Walter. Supplementary reading. Prerequisite, Zoölogy 1; 3 lectures. Credit, 3. Associate Professor McLean.

6. Live-stock Management. — The work of this course consists of laboratory work by the individual students in the handling of live stock; with horses, such work as halter breaking, breaking to drive, driving, harnessing, casting and fitting for show will be done; similarly, the practical handling of cattle, sheep and swine will be fully treated. Special study is given to halter making, splicing, hitches, knots and all rope work. Prerequisite, Animal Husbandry 3. Juniors; 1 laboratory period. Credit, 1. Mr. Quaife.

8. Advanced Stock Judging. — This course is designed to equip Animal Husbandry students in the judging of classes of different types of live stock; to strengthen them in the selection of superior sires; and equip them for stock judging at fairs. Visits will be made to the best herds for the various breeds of stock in the State. Judging teams to represent the college will be selected largely from this class. Prerequisite, Animal Husbandry 3. Juniors; 2 laboratory periods. Credit, 2. Associate Professor McLean.

9. Feeding and Management. — A study of the principles of animal nutrition; of the composition and qualities of feeding materials; of the feeding, care and management of dairy cattle from birth to maturity, with especial attention to economic production. Text-book, Henry's "Feeds and Feeding." Prerequisite, Chemistry 5 or 7. Seniors; 3 lectures. Credit, 3.

Mr. Quaife.

10. Feeding and Management. — A continuation of Course 9, dealing in a similar manner with horses, sheep, beef cattle and swine. Prerequisite, Course 9. Seniors; 3 lectures. Credit, 2. Mr. Quaife.

11. Herd and Stud-book Study. — An advanced course in the study of the breeds of live stock, familiarizing the student with the detailed history of the breed, the most productive sires and dams of the various breeds, and the successful lines and methods of breeding. Prerequisites, Animal Husbandry 5 and 8. Seniors; 2 hours. Credit, 2. Associate Professor McLean.

DAIRYING.

Professor Lockwood, Mr. Story, Mr. Coons.

Elective Courses.

1. Milk and Milk Composition. — The development of the dairy business in the United States; the composition, secretion and general characteristics of milk; contamination and fermentation; the study of analysis of milk products by use of the Babcock test for fat, test for acidity and adulteration, and ordinary preservatives; moisture tests for butter; methods for testing herds and developing them to higher efficiency; problems. Two lecture hours and 1 2-hour laboratory period. Credit, 3.

Professor Lockwood.

2. Buttermaking. — A study of separators and cream separation; handling milk and cream for buttermaking; preparation of starters, and ripening cream; churning; markets and their requirements; marketing, scoring and judging butter; management; problems; dairy machinery and care thereof. Prerequisite, Course 1; 1 lecture hour and 2 2-hour laboratory periods. Credit, 3. Professor Lockwood and Mr. Coons.

3. Market Milk and Milk Products. — A study of market milk conditions, extent and development of the business; supply and delivery; food value of milk and its use as food; milk and its relation to the public health; methods for the proper handling and preparing of milk and cream for direct consumption; certified milk, requirements and production; pasteurizing; sterilizing; standardizing and modifying; milk laws and inspection. The manufacture of milk products other than butter, including cheese, condensed milk, cottage cheese, casein, milk powder, ice cream, etc. Prerequisites, Dairying 1, and Bacteriology 1; 2 lecture hours and 1 2-hour laboratory period. Credit, 3. Professor Lockwood.

4. Dairying. — A course designed primarily for teachers of secondary agriculture. The work given will cover briefly the composition and secretion of milk, the Babcock fat test, the relation of bacteria to dairy work and principles of creaming; separators; elementary buttermaking; proper methods of handling milk and cream; and the relation of market milk to the public health. One lecture hour and 2 2-hour laboratory periods. Credit, 3.
Professor Lockwood.

FARM ADMINISTRATION.

Professor Foord.

Elective Courses.

3. Farm Buildings and Machinery. — A study of the material equipment of the farm aside from the land; farm buildings, their location, plan and arrangement; water supply; fencing problems; farm power; farm machinery; wagons. Prerequisites, Agronomy 1, Animal Husbandry 2, Physics 1. Primarily for seniors; 2 laboratory periods and 1 lecture hour. Credit, 3.
Professor Foord.

4. Farm Management. — The organization of the farm as a business enterprise. A discussion and study of some of the problems that confront the modern farmer, such as the choice of a farm, systems and types of farming, labor, marketing, records and farm accounts. Prerequisites, Agronomy 1 and 3, Animal Husbandry 2 and 3. Primarily for seniors; 2 lecture or recitation hours and 1 laboratory period. Credit, 3. Professor Foord.

POULTRY HUSBANDRY.

Professor Graham, Mr. Brown.

Elective Courses.

1. Elements of Poultry Culture. — This course consists of a comprehensive study of poultry-house construction, poultry-house equipment, winter-egg production, types and breeds of poultry. Juniors; 2 lectures. Credit, 2.
Professor Graham.

2. Elements of Poultry Culture. — This is a continuation of Course 1, treating the subjects of incubation, brooding, care of growing stock, market poultry, including capons, roasters and broilers, and diseases of poultry. Juniors; 2 lectures. Credit, 2. Professor Graham.

3. Poultry Practice Work. — This is a practical laboratory course in poultry carpentry, caponizing, killing and picking; dressing and packing poultry, sorting and preparing eggs for market. Must be preceded or accompanied by Course 1. Juniors; 1 laboratory period. Credit, 1.
Mr. Brown.

4. Incubation and Brooding. — In this course students are required to set up and operate incubators and brooders, make a systematic study of the development of the chick in the egg, and the care of sitting hens. This course must be preceded or accompanied by Course 2. Juniors; time to be arranged. Credit, 1 to 3. Mr. Brown.

5. Pen Management. — This is a practical laboratory course. Students are required to care for a pen of fowls, keeping accurate records of eggs produced, food consumed, weather conditions, health of fowls, and profit and loss; must be preceded or accompanied by Course 1. Juniors; time to be arranged. Credit, 1. Mr. Brown.

6. Poultry Management. — In this course a detailed study of large poultry farms and equipment, such as bone cutters, feed cutters, cramming machines, etc., will be carried on. It includes the laying out and planning of poultry buildings of all kinds, the mating of fowls, and the preparing of birds for exhibition. Attention to poultry diseases and investigation work carried on by experiment stations is prominent in this course. A few good poultry plants will be visited by the class for practical demonstrations. Prerequisites, Courses 1, 2, 3 and 4. Seniors; 2 lectures, 1 laboratory period. Credit, 3. Professor Graham and Mr. Brown.

7. Advanced Poultry Judging. — This course includes a study of the origin and history of breeds and varieties, poultry organizations and poultry shows. The American Standard of Perfection will be used as a text. Prerequisites, Courses 1, 2, 3, 4 and 5. Seniors; 1 lecture and 2 laboratory periods. Credit, 3. Mr. Brown.

9. Market Poultry and Poultry Products. — This course includes the study of market classifications of poultry, eggs and feathers; the requirements of different markets, methods of marketing, advantages and disadvantages of cold storage of poultry and eggs. Students will be required to fatten several lots of chickens by different methods and rations. Accurate data must be kept showing the gain in weight and quality, also the cost of feed, labor, etc., and the profit and loss. Judging and scoring of market poultry, both alive and dressed, and market eggs will be an important feature of this course. Prerequisites, Courses 1, 2 and 3. Seniors; 1 lecture or conference period and laboratory periods to be arranged. Credit, 3.
Mr. Brown.

DIVISION OF HORTICULTURE.

Professor WAUGH.

[The general subject of horticulture divides naturally into the subjects of pomology, floriculture, forestry, landscape gardening and market gardening. A number of courses relate to more than one of these subjects, and are therefore grouped here under the general designation of horticulture.]

2. NURSERY PRACTICE. — This course treats of the fundamental methods of plant propagations by seeds, cuttings, budding, grafting, etc. Lectures and practicums. Sophomores, 1 lecture period and 1 laboratory period. Credit, 2. Assistant Professor CHENOWETH.

Elective Courses (General).

3. PLANT MATERIALS. — This course aims to make the student familiar with the character of the trees, shrubs and herbaceous perennials used in ornamental work, and with the methods of propagating them. Prerequisite, Horticulture 2; 2 lecture periods and 1 laboratory period. Credit, 3.

4. PLANT MATERIALS. — A continuation of Course 3, taking up the field use of trees, shrubs and herbaceous plants, their native habitats, soils and plant associations, with a view to supplying to students in landscape gardening and floriculture a knowledge of plant species. Frequent practicums and field excursions. Prerequisite, Horticulture 3; 2 lecture periods and 1 laboratory period. Credit, 3.

6. PLANT BREEDING. — This course is designed to introduce advanced students to the best modern views of variation, heredity and evolution, and to the best methods of studying the phenomena found in these subjects. The principles educed apply to both animal breeding and plant breeding, but the laboratory work (of which there is considerable) is concerned chiefly with plant life. Some practice work in hybridization and selection is undertaken, and students are trained as far as possible in the practical application of those principles which have direct bearing on the breeding of plants and the cultivation of crops. Seniors and graduates; open only to students well prepared in agricultural or horticultural subjects; 2 lecture periods and 1 2-hour laboratory period. [Not given in 1914–15.] Credit, 3.

FLORICULTURE.

Elective Courses.

1. GREENHOUSE MANAGEMENT. — This course is designed to familiarize students with methods followed in the management of greenhouse crops. The students are instructed in the practical operation of glazing concrete, bench construction, bulb culture, greenhouse watering, fumigating and ventilating, in the care of furnaces, and in the methods of propagation of greenhouse plants by seeds and cuttings. This is designed as a laboratory course,

and students electing it will be expected to arrange their hours according to the needs of the work. Prerequisite, Horticulture 2. Juniors; 7 hours a week. Credit, 4.

2. Greenhouse Management. — A continuation of Course 1, including also a study of the location, arrangement and construction of greenhouses; the drawing of plans for commercial and private ranges, to show foundations and details in construction of superstructure; arrangement of heating pipes; estimate of comparative cost of different methods of construction; drafting specifications. Design making and table decorations are considered in this course. Juniors; prerequisite, Floriculture 1; 7 hours as stated under Course 1. Credit, 4.

3. Fall Greenhouse Crops. — A study of important fall and winter crops and their care, — chrysanthemums, carnations, violets, roses, palms and various conservatory plants; the importation, purchase and growth of bulbous material; the preparation of material for forcing; house and church decorating. Lectures, text-books and laboratory exercises. Prerequisites, Floriculture 1 and 2. Seniors; 5 hours. Credit, 3.

4. Spring Greenhouse Crops. — The culture of individual crops in their relation to spring work in a florist establishment. A critical study of methods of propagating bedding plants, the nature and use of these plants, practice in planting them and in the spring care of herbaceous perennials and wholesale and retail marketing of spring plants. Lectures, text-books and practical exercises. Seniors; prerequisites, Floriculture 1, 2 and 3; 5 hours. Credit, 3.

MICROBIOLOGY.

Dr. Marshall, Dr. van Suchtelen, Mr. Itano, ————.

Elective Courses.

1, 2. Morphological, Cultural and Physiological Microbiology. — Types of micro-organisms, technic of handling, methods of culture and functions of micro-organisms are considered. This course is elementary and fundamental to all applied and special microbiological studies, and therefore is made a prerequisite to all courses offered; 2 hours or 2 credits are assigned to lectures, text-book requirements and recitations; this time will be scheduled. Six hours or 3 credits are assigned to laboratory exercises; only 1 hour of the 6 is scheduled, the remaining 5 hours are arranged with the instructor. Total, 5 credits. Open to juniors and seniors during the fall and spring semesters.

3, 4. Agricultural Microbiology. — This general comprehensive course is designed to cover in an elementary manner those subjects only which confront the student of general agriculture, — the microbiological features of air, water, sewage, soil, dairy, fermentations, food, vaccines, antisera, microbial plant infections, methods and channels of infections, immunity and susceptibility, microbial infections of man and animals, methods of control or sanitary and hygienic practices. .These subjects will be demonstrated by illustrative and typical laboratory exercises, which for each subject, on account of time limitations, must be very elementary and greatly restricted. Prerequisite,

Microbiology 1 and 2. Two hours or 2 credits are assigned to lectures, textbook requirements and recitations; this time will be scheduled. Six hours or 3 credits are assigned to laboratory exercises; only 1 hour of the 6 is scheduled; the remaining 5 hours are arranged with the instructor. Total, 5 credits. Open to juniors and seniors during the fall and spring semesters.

NOTE. — Courses 1 and 2 are especially adapted to those who wish a general, comprehensive, although elementary, survey of Agricultural Microbiology.

5, 6. ADVANCED MORPHOLOGICAL, CULTURAL AND PHYSIOLOGICAL MICROBIOLOGY. — The purpose of this course is to prepare the student for a more intimate knowledge of microbiological agricultural problems. To accomplish this object it is necessary to provide more advanced technic and methods of culture, together with a more extensive knowledge of micro-organisms and their functions. Prerequisites, Microbiology 1 and 2, 3 and 4; Chemistry 5 and 6. Six hours or 3 credits are assigned to laboratory exercises; only 1 hour of the 6 is scheduled; the remaining 5 hours are arranged with the instructor. Total, 3 credits. Open to juniors and seniors in the fall and spring semesters.

7, 8. ADVANCED AGRICULTURAL MICROBIOLOGY. — A knowledge of the subjects mentioned in Courses 3 and 4 cannot be obtained without a more extensive training in microbiological practices, as found in Courses 5 and 6. With this it is possible to continue the work of Course 2. Prerequisites, Microbiology 1 and 2 and 3 and 4, 5 and 6; Chemistry 5 and 6. Six hours or 3 credits are assigned to the laboratory exercises; only 1 hour of the 6 is scheduled; the remaining 5 hours are arranged with the instructor. Total, 3 credits. Open to juniors and seniors in the fall and spring semesters.

9, 10. SOIL MICROBIOLOGY. — Such subjects as the number and development of micro-organisms in different soils; the factors which influence their growth, food, reaction, temperature, moisture and aeration; the changes wrought upon inorganic and organic matter in the production of soil fertility, ammonification, nitrification and denitrification; fixation of nitrogen symbiotically and non-symbiotically; methods of soil inoculation receive attention. Prerequisite, Microbiology 1 and 2. Six hours or 3 credits are assigned to laboratory exercises; only 1 hour of the 6 is scheduled; the remaining 5 hours are arranged with the instructor. Open to juniors and seniors during the fall and spring semesters.

11, 12. DAIRY MICROBIOLOGY. — Special emphasis will be placed upon milk supplies. The microbial content of milk, its source, its significance, its control; microbial taints and changes in milk; groups or types of organisms found in milk; milk as a carrier of disease-producing organisms; the value of straining, aeration, centrifugal separation, temperature, pasteurization; the abnormal fermentations of milk; bacteriological milk standards and their interpretation; ripening of milk and cream; the bacterial content of butter; a passing survey of the microbiology of cheeses; a study of special dairy products, as ice cream, condensed milk, artificial milk drinks (the products of microbial actions), represents a list of topics considered. Prerequisite, Microbiology 1 and 2, and Dairying 1. Six hours or 3 credits are assigned to labora-

tory exercises; only 1 hour of the 6 is scheduled; the remaining 5 hours are arranged with the instructor. Open to juniors and seniors during the fall and spring semesters. (See Dairying 3.)

13, 14. Food Microbiology. — A study of food preservation by means of drying, canning, refrigerating and addition of chemicals will be pursued. Food fermentations, as illustrated by bread, pickles, sauerkraut, ensilage, vinegar, wine, etc., will be examined. Decomposition of foods, as may be seen in meat, oysters, fish, milk, etc., as well as diseased foods, will receive consideration. Contamination of food supplies by means of water, handling, exposure, diseased persons, etc., is of especial significance and will be demonstrated by laboratory exercises. Prerequisite, Microbiology 1 and 2. Six hours or 3 credits are assigned to laboratory exercises; only 1 of the 6 is scheduled; the remaining 5 hours are arranged with the instructor. Open to juniors and seniors during the fall and spring semesters.

15, 16. Hygienic Microbiology. — An attempt will be made to select for this course certain material which should be the possession of every individual, and which is basic to public hygiene and sanitation, as applied to man and animals. The microbiology of water supplies, food supplies, vaccines, antisera or antitoxins; the channels by which micro-organisms enter the body, the influence of body fluids and tissues upon them, body reactions with micro-organisms (susceptibility and immunity); the micro-organisms of some of the most important infectious diseases, methods of control, including disinfectants and disinfection, antiseptics, antisepsis and asepsis will be treated. Prerequisite, Microbiology 1 and 2. Six hours or 3 credits are assigned to laboratory exercises; only 1 of the 6 is scheduled; the remaining 5 hours are arranged with the instructor. Open to juniors and seniors during the fall and spring semesters.

FORESTRY.

Professor Clark.

Elective Courses.

1. Principles of Forestry. — A lecture course for the purpose of giving the students a general view of the whole field of forestry and what forestry attempts to accomplish and has accomplished. Two lectures; juniors and seniors; not required of students who propose to major in forestry. Credit, 2. Professor Clark.

3. Dendrology. — During the first part of the semester frequent field trips will be made to identify and study the habits of our native forest trees. Later, the classification, range, distribution, forest habits, quality, uses and identification of wood of the commercial timber trees of the United States will be studied. Two 2-hour periods; lectures, recitations, laboratory or field work at option of instructor; juniors. Credit, 3. Professor Clark.

4. Silviculture. — Factors influencing forest growth; forest types; silvicultural systems; care and protection of forests; forest description; forest nursery practice and forest planting. Three lectures weekly until May 1; during May and June, 1 lecture and 1 4-hour field period weekly; juniors. Prerequisite, Forestry 3. Credit, 3. Professor Clark.

5. Forest Mensuration. — Methods of determining the volume of trees, logs and entire forests. Methods of computing volume tables, tree and forest growth and yield tables. Timber estimating. Three lectures; 72 hours of field work; seniors. Credit, 5. Professor Clark.

6. Forest Valuation and Regulation. — Methods of determining the costs of growing timber crops and of arriving at the value of future growth or standing immature growth. Methods of regulating the harvest of crops so as to secure a sustained or annual yield. Prerequisite, Forestry 5; seniors; 3 lectures. Credit, 3. Professor Clark.

LANDSCAPE GARDENING.

Professor Waugh, Assistant Professor Harrison.

Elective Courses.

1. Elements of Landscape Gardening. — Reconnoissance surveys and mapping, with special reference to the methods used in landscape gardening; detailed study of selected designs of leading landscape gardeners; grade design, road design and field work. Students should have preparation in surveying, mathematics, plant materials and drawing. Must be followed by Course 2. Juniors; 6 hours a week. Credit, 3.
Assistant Professor Harrison.

2. Elements of Landscape Gardening. — As stated under Course 1. Prerequisite, Course 1.

3. General Design. — Field notes; examination of completed works and those under construction; design of architectural details, planting plans, gardens, parks and private grounds; written reports of individual problems. Seniors; prerequisites, Landscape Gardening 1 and 2, and either plant materials (Horticulture 3 and 4) or advanced mathematics; must be followed by Course 4; 6 hours. Credit, 3. Assistant Professor Harrison.

4. General Design. — As stated under Course 3. Prerequisite, Course 3.

5. Theory of Landscape Art. — The general theory and applications of landscape study, including a brief history of the art. Seniors and graduates; 2 hours. Credit, 2. Professor Waugh.

6. Architecture. — The history of architectural development, the different historic types, with special reference to the underlying principles of construction and design and their relations to landscape design. Illustrated lectures, conferences, pcratice in designing; 2 hours. Credit, 2. (Alternating with Course 10 and not to be given in 1913–14.)
Assistant Professor Harrison.

7. Civic Art. — The principles and applications of modern civic art, including city design, city improvement, village improvement and rural improvement. Prerequisites, Courses 1, 2 and 3; must be followed by Course 8; 6 hours. Credit, 3. Professor Waugh.

8. Civic Art. — As stated under Course 7. Prerequisite, Course 7.

10. Construction and Maintenance. — Detailed instruction in methods of construction and planting in carrying out plans, in organization, reporting, accounting, estimating, etc.; maintenance work in parks and on estates, its organization, management, cost, etc. Two hours. Credit, 2. (Alternating with Course 6.) Assistant Professor Harrison.

MARKET GARDENING.

Mr. Georgia.

Elective Courses.

2. Elements of Market Gardening. — A course designed for an introduction to market gardening as a business. The work consists primarily of actual field experience in handling vegetable crops from seed to maturity. This is supplemented with lectures and text-book, in which a study of methods, soils, fertilization, tillage and management is made. Juniors; 5 hours. Credit 3. Mr. Georgia.

3. Advanced Market Gardening. — A continuation of the work begun in Market Gardening 2, taking up problems of seed growing, selection of varieties, crop management, harvesting, storage and marketing. A study is made of the greenhouse vegetable industry, and considerable time devoted to growing the special forced crops. Some time is given to a systematic study of vegetable description, classification and nomenclature. Collateral reading is required. Seniors; prerequisite, Market Gardening 2; 5 hours. Credit, 3. Mr. Georgia.

POMOLOGY.

Professor Sears, Mr. Chenoweth, Mr. Rees.

Elective Courses.

1. Practical Pomology. — *General.* — A study of the general principles of the growing of fruits, dealing with such questions as selection of site, soils, windbreaks, laying out plantations, choice of nursery stock, pruning, etc. Text and reference books; field and laboratory exercises. Prerequisite, Horticulture 2. Juniors; 4 hours. Credit, 3. Professor Sears.

2. Practical Pomology. — *Special.* — The special application of the general principles discussed in Course 1 to the culture of the principal kinds of fruits, such as apples, pears, peaches, plums, cherries and quinces; grape culture and the culture of small fruits, such as blackberries, raspberries, currants, gooseberries and strawberries. Text-books, lectures and reference books; field and laboratory exercises. Prerequisites, Horticulture 2 and Pomology 1. Juniors; 4 hours. Credit, 3. Professor Sears.

3. Systematic Pomology. — A study of the varieties of the different fruits and of nomenclature, with critical descriptions; special reference being given to relationships and classification. Text-books, laboratory and field exercises. Prerequisites, Horticulture 2 and Pomology 1 and 2. Seniors; 4 hours. Credit, 3. Professor Chenoweth.

4. Commercial Pomology. — The storing and marketing of fruits; includes a discussion of storage houses, the handling and storing of fruits, fruit packages, methods of grading and packing, etc. Text and reference books; laboratory exercises. Seniors; prerequisites, Horticulture 2, Pomology 1, 2 and 3; 4 hours. Credit, 3. Professor Chenoweth.

6. Spraying. — A study of (*a*) spraying materials, their composition, manufacture and preparation for use; the desirable and objectionable qualities of each material, formulas used, cost, tests of purity. (*b*) Spraying machinery, including all the principal types of pumps, nozzles, hose and vehicles; their structure and care. (*c*) Orchard methods in the application of the various materials used, with the important considerations for spraying each fruit and for combating each orchard pest. This course is designed especially to familiarize the student with the practical details of actual spraying work in the orchard. Spray materials are prepared, spraying apparatus is examined and tested, old pumps are overhauled and repaired, and the actual spraying is done in the college orchards and small fruit plantations. Prerequisites, Horticulture 2, Pomology 1 and 2. Seniors; 3 hours (1 lecture period and 1 laboratory period). Credit, 2. Professor Sears.

DRAWING.

Mr. Hillary.

Elective Courses.

1. Freehand Drawing. — Lettering; freehand perspective; sketching from type models, leaves, flowers and trees, houses, etc.; laying flat and graded washes in water colors; water color rendering of leaves, flowers and trees; conventional coloring and map rendering in water colors; conventional signs and mapping in ink. Juniors; 6 hours. Credit, 3.
Mr. Hillary.

2. Mechanical Drawing. — Inking exercises; geometric problems; projection; intersections, isometric; shades and shadows; parallel; angular and oblique perspective; perspective drawing of buildings. Students should have preparation in plane and solid geometry. Juniors; 6 hours. Credit 3.
Mr. Hillary.

DIVISION OF SCIENCE.

Professor Paige.

BOTANY.

Professor Stone, Assistant Professor Osmun, Mr. McLaughlin, Mr. Smith.

[The object of the courses in botany is to teach those topics pertaining to the science which have a bearing upon economic and scientific agriculture. Undergraduate work extending through five semesters is offered. Considerable latitude is allowed students in the senior year in their electives; and, besides the courses here outlined, students often take up the study of histology or of systematic botany, the microscopic examination of pure and adulterated human and cattle foods, spices and drugs, etc. Students sufficiently prepared are occasionally permitted to undertake special physiological and pathological investigations. A botanical conference is held monthly wherein new problems in botanical science are considered by graduate students and the seniors who elect botany.]

Required Course.

2. General Botany. — The morphology, physiology and classification of plants. This course is fundamental. Its aim is to lay a foundation for the more specialized courses in botany which follow and to provide a general knowledge of the science for those students who will not take further work in the department. This course is prerequisite to all other courses given by the department. Laboratory work consists in the microscopic study of representatives of all the more important plant groups. This phase of the work is almost entirely devoted to morphology and histology, especial attention being given to the structure of higher plants. The lectures aim to amplify and interpret the laboratory work, dealing also with the function (physiology), classification (taxonomy) and ecology of plants. Each student is required to collect and prepare an herbarium of 75 species of native plants. Gray's "New Manual of Botany" is used in determining and naming plants. Though only 1 lecture period is scheduled for this course, it is understood that laboratory hours may be used for lectures at the discretion of the instructor. Sophomores; 1 lecture; 3 laboratory periods. Credit, 4.

Assistant Professor Osmun and Mr. McLaughlin.

Elective Courses.

3. Cryptogamic Botany. — Systematic study of typical forms of the lower plants (bacteria, algæ, fungi, lichens, mosses and ferns); instruction in laboratory technique and methods, and the making of herbaria of lichens, mosses and ferns. Laboratory work and lectures; field excursions for the purpose of observing environmental habits and collecting material for laboratory study; collateral reading. This course is intended for those students who wish to specialize in biology; its purpose is to afford more thorough scientific training than is offered in Course 5, and students electing this course may attend the lectures in Course 5. Prerequisite, Botany 2. Primarily for juniors. One lecture hour and 3 2-hour laboratory periods. Credit, 4.

Assistant Professor Osmun.

4. Cryptogamic Botany. — This is a continuation of Course 3. Prerequisites, Botany 2 and 3. Primarily for juniors; 1 lecture hour and 2 2-hour laboratory periods. Credit, 2. Assistant Professor Osmun.

5. Plant Pathology. — This course comprises a study of the common diseases of crops and consideration of the methods for their prevention and control, and is intended especially for students in horticulture and agriculture. Laboratory work and lectures. Prerequisite, Botany 2. Primarily for juniors; 1 1-hour lecture and 1 2-hour laboratory period. Credit, 2.

Professor Stone, Assistant Professor Osmun and Mr. McLaughlin.

7. Plant Pathology. — This course includes a study of the diseases of one or more crops and the methods of controlling them. Laboratory work and lectures, together with extensive reading of experiment station literature. The course is intended for those who wish to become more familiar with the diseases of one or more groups of economic plants. Prerequisite, Botany 2. Seniors; students who take this course and continue in botany must take Course 8; 1 lecture period and 3 3-hour laboratory periods. Credit 5. Professor Stone.

8. Plant Pathology. — As stated in Course 7. Prerequisite, Course 7.

9. Economic Fungi. — This course comprises the study of economic fungi from a technical point of view, and is intended for those students who wish for a more comprehensive knowledge of the phylogenetic relationship of fungi. Laboratory work and lectures. Problems of a practical or technical nature intimately associated with the control of diseases are taken up Special monographs and more important station literature treating of the life history of fungi, etc., are studied. Prerequisites, Botany 2, 3 and 4. Must be followed by Course 10; seniors; 1 1-hour lecture period and 2 or 3 3-hour laboratory periods. Credit, 4 or 5. Professor Stone.

10. Economic Fungi. — As stated in Course 9. Prerequisite, Course 9.

11. Plant Physiology. — This course is largely experimental and is especially adapted to the needs of students who are taking chemistry. Laboratory work and lectures; various handbooks on plant physiology. Prerequisite, Botany 2. Must be followed by Course 12; seniors; 1 1-hour lecture period and 3 3-hour laboratory periods. Credit, 5.

Professor Stone and Mr. McLaughlin.

12. Plant Physiology. — As stated in Course 11. Prerequisite, Course 11.

13. Shade-Tree Management. — Physiology and pathology of shade trees. This course includes a comprehensive study of the diseases, structure and functions of trees and shrubs, and of every agency which in any way affects shade trees. Laboratory work and lectures; extensive reference reading. Designed for those students who intend to take charge of parks or large estates, or to become tree wardens, city foresters, landscape gardeners or professional advisers and caretakers. Prerequisite, Botany 2. Must be followed by Course 14; seniors; 1 1-hour lecture period and 2 3-hour laboratory periods. Credit, 4. Professor Stone.

14. Shade-Tree Management. — Physiology and pathology of shade trees. As stated in Course 13. Prerequisite, Course 13.

15. Histological Technique. — This course comprises training in general histological methods, including the use of precision microtomes, various methods of killing, fixing, sectioning, staining and mounting of plant materials. This is a technical course in histology, of value to students intending to become research or teaching botanists. It is recommended for students taking Courses 9 and 10, as an aid to the study of relationship between host and parasite, and is open to those taking Courses 13 and 14 who desire to make their studies in tree structure more comprehensive than provided for in these courses. Collateral reading and conferences. Prerequisites, Botany 2, 3 and 4. Seniors; 3 or 5 2-hour laboratory periods. Credits, 3 or 5.

Assistant Professor Osmun.

16. Histological Technique. — This is a continuation of Course 15. Prerequisite, Course 15. Seniors; 3 or 5 2-hour laboratory periods. Credits, 3 or 5. Assistant Professor Osmun.

GENERAL AND AGRICULTURAL CHEMISTRY.

Professors Lindsey, Wellington and Chamberlain, Associate Professor Peters, Assistant Professor Anderson, Messrs. Bogue, Fowler, Serex, Robinson and Brown.

[The course in chemistry aims to teach accurate observation, logical thinking and systematic and constant industry. It likewise aims to give those students following the several agricultural occupations, or who are preparing themselves for work as teachers and investigators in the other sciences, a knowledge of the subject sufficient to enable them to apply it in their various lines of work. Students taking all of the undergraduate courses and who intend following chemistry as a vocation are prepared for positions as instructors in high schools and colleges, in the agricultural experiment stations, the United States Department of Agriculture, as well as in fertilizer, cattle food, sugar and dairy industries. Students are encouraged to take graduate work leading especially to the degree of M.Sc., and to thus prepare themselves for advanced positions as teachers in the agricultural colleges, as research chemists, and likewise for the more responsible positions connected with the different agricultural industries of the country. A fuller knowledge of the course of instruction will be found by consulting the following outline.]

Required Courses.

1. General Chemistry. — *The Non-metals.* — An introduction to the fundamental chemical laws, together with a study of the common acid forming elements and their compounds. Kahlenberg's "Outlines of Chemistry" is used as a text. The laboratory work is of two kinds. Those beginning the subject form one division and those who present chemistry for entrance are grouped in other divisions. The advanced divisions, in addition to work not usually done in high schools, study simple volumetric quantitative processes such as the determination of the hardness of water, the available oxygen in hydrogen peroxide, the chlorine in soluble chlorides, the oxygen in bleaching powder and the strengths of solutions of acids and bases. Freshmen; lectures, 2 hours; laboratory, 2 hours. Credit, 3.

Associate Professor Peters, Assistant Professor Anderson, Mr. Bogue and Graduate Assistants.

2. General Chemistry. — *The Metals.* — A continuation of Course 1. A study of the metals and their compounds. The laboratory work takes the synthetic form. Substances of agricultural importance are prepared in quantity and studied in detail by the student. These include ammonium sulfate from gas liquor, sulfur and arsenic insecticides and superphosphates,

in addition to preparations outlined in Blanchard's "Synthetic Inorganic Chemistry." Attention is paid to the subjects of mass action and colloids. Prerequisite, Course 1. Freshmen; lectures, 2 hours; laboratory, 2 hours. Credit, 3.

Assistant Professor Anderson, Associate Professor Peters, Mr. Bogue and Graduate Assistants.

Elective Courses.

3. Qualitative Analysis. — *Basic.* — A course in the systematic analysis of metallic salts, presented from the ionic viewpoint. The student studies closely the tests used in the separation and identification of the metals; he then applies these tests to unknown mixtures. Text, Medicus' "Qualitative Analysis," with Böttger's "Qualitative Analysis" and Treadwell-Hall's "Qualitative Analysis" for reference. Prerequisite, Course 2; should be taken, particularly, by all intending to follow chemistry as a vocation. Sophomores; lecture, 1 hour; laboratory, 4 hours. Credit, 3.

Assistant Professor Anderson and Mr. Serex.

4. Qualitative Analysis. — *Acidic.* — A continuation of Course 3. A large part of the semester is spent in the examination qualitatively of minerals and of agricultural products. Prerequisite, Course 3. Sophomores; lecture, 1 hour; laboratory, 4 hours. Credit, 3.

Assistant Professor Anderson and Mr. Serex.

5. Organic Chemistry. — This course, with Course 6, continues through the junior year. The two courses are designed especially: (1) for those who are looking forward to positions as chemists in agricultural colleges or experiment stations, the United States Department of Agriculture, or similar places, and who need a knowledge of chemistry for itself; and (2) for those who are expecting to enter like positions in other sciences, and who will use their knowledge of chemistry in a secondary way. It consists of a systematic study, both from texts and in the laboratory, of the more important compounds in the entire field of organic chemistry. Especial attention is given to those compounds which are found in agricultural products or are manufactured from them. These include alcohols, acids, esters, fats, carbohydrates, proteins, etc. The work forms a foundation for courses in physiological chemistry and agricultural analysis, and thus for future work in agricultural chemical investigation. Prerequisites, Courses 1, 2, 3 and 4 (courses 3 and 4 will not be required as prerequisites for those majoring in other courses than chemistry). Juniors; those electing Course 5 are expected to elect Course 6. Lectures, 3 hours; laboratory, 4 hours. Credit, 5.

Professor Chamberlain and Mr. Fowler.

6. As stated under Course 5.

Professor Chamberlain and Mr. Fowler.

7. Agricultural Chemistry. — This course and Course 8 are designed as alternatives for Courses 5 and 6. They are especially intended for those who, having completed Courses 1 and 2, do not care to continue the study of chemistry for itself, but are planning to enter practical agricultural work and desire a further knowledge of chemistry as it is related directly to practical

agriculture and agricultural problems. The work is planned in two parts, viz.: *Course 7, Inorganic Agricultural Chemistry*, the study of the general composition, properties and reactions of soils and fertilizers, and in addition to this the study of some of the more important fungicides and insecticides, and the common materials of construction, such as tile, brick, cements, paints, oils, etc.; and *Course 8, Organic Agricultural Chemistry*, the study of the composition, physiological processes, uses and nutritive value of plants, and the composition and general processes of nutrition and growth of animals; also the study of products related to plants and animals, such as milk, butter, sugar, maple syrup, denatured alcohol, wood pulp, paper, etc. The treatment of the subject in both of these courses is entirely general, avoiding all complicated chemical facts and relationships, and endeavoring simply to make the student acquainted with the chemical aspects of agricultural processes and products. Prerequisites, Courses 1 and 2. Juniors; those electing Course 7 are expected to elect Course 8. Lectures, 2 hours; laboratory, 2 hours. Credit, 3. Professor WELLINGTON and Mr. FOWLER.

8. ORGANIC AGRICULTURAL CHEMISTRY. — As stated under Course 7.
Professor CHAMBERLAIN and Mr. FOWLER.

9. QUANTITATIVE ANALYSIS. — Instruction in this course includes the gravimetric and volumetric determinations of some of the commoner metals and non-metals in minerals and industrial products. Aside from teaching accurate observation and care in manipulation, it is intended for those who would learn the exact methods for determining the elements, particularly, in inorganic substances, and is the forerunner of other courses intended to fit men to become expert analysts. Talbot's "Quantitative Chemical Analysis" is used as a text. Prerequisites, Courses 1, 2, 3 and 4. Juniors; lecture, 1 hour; laboratory, 8 hours. Credit, 5.
Professor WELLINGTON and Assistant.

10. AGRICULTURAL CHEMICAL ANALYSIS. — In this course and Course 11 the methods previously studied, and other approved methods, are applied to the examination of agricultural materials. The analysis of fertilizers, insecticides, fungicides and soils is followed by that of cattle foods, dairy products, sugars, starches and allied substances. Prerequisite, Course 9. Juniors; lecture, 1 hour; laboratory, 8 hours. Credit, 5.
Professor WELLINGTON and Assistant.

11. AGRICULTURAL CHEMICAL ANALYSIS. — As stated under Course 10. Prerequisite, Course 10. Seniors; lecture, 1 hour; laboratory, 8 hours. Credit, 5. Associate Professor PETERS and Assistant.

13. PHYSIOLOGICAL CHEMISTRY. — This course is intended to be supplementary to Courses 5 and 6 and Courses 7 and 8. To those who expect to take up scientific work in botany, agronomy, animal husbandry, bacteriology, etc., and who have had Courses 5 and 6, it will give acquaintance with the chemistry of the physiological processes in plants and animals, by means of which some of the important organic compounds studied in Courses 5 and 6 are built up in the living organism or are used as food by it. In the lectures the study of food and nutrition as related to both human and domestic ani-

mals is the principal subject. In the laboratory, experimental studies are made of the animal body and the processes and products of digestion, secretion and excretion. The course gives additional training in the chemical problems of agricultural experiment station work, especially those connected with investigations in animal and plant nutrition. To those who will not take up scientific lines of work, but will follow practical agriculture, it will give an opportunity for a more detailed study of the chemistry and physiology of problems which were treated generally in Courses 7 and 8. Prerequisites, preferably, Courses 5 and 6 or 7 and 8. Seniors; lectures, 2 hours; laboratory, 2 hours. Credit, 3. Professor CHAMBERLAIN and Mr. FOWLER.

15. PHYSICAL CHEMISTRY. — A résumé of general chemistry from the viewpoint of physical chemistry and the application of physical chemistry to agricultural chemistry. Prerequisite, Course 9. Juniors and seniors; lectures, 2 hours; laboratory, 2 hours. Credit, 3.
Assistant Professor ANDERSON and Mr. SEREX.

[GENERAL STATEMENT CONCERNING COURSES 12, 14 AND 16. — Each student electing either of these courses will be required to take up and follow out some special line of work, the object being to acquaint him with methods of original inquiry. A single concrete example may be found in a comparative study of the different methods for the determination of the several forms of nitrogen. A thesis may not be required, but frequent consultation of the literature bearing on the subject will be necessary. These courses are valuable for all chemists, and particularly so for those intending to take up experiment station work. A student may choose any one but not two of these separate courses.]

12. SPECIAL WORK IN AGRICULTURAL CHEMICAL ANALYSIS. — Topics for laboratory study will be assigned to each student. Prerequisite, Course 11. Seniors; laboratory, 10 hours. Credit, 5. Associate Professor PETERS.

14. SPECIAL WORK IN PHYSIOLOGICAL AND ORGANIC AGRICULTURAL CHEMISTRY. — In this course, as in Courses 12 and 16, the student will be able to give his attention primarily to one line of chemical study. To those whose tastes and interests are in connection with the organic and physiological problems of agricultural chemistry, many subjects of study present themselves, among which may be mentioned: proteins, carbohydrates, fats, organic nitrogenous compounds in fertilizers and soils and their relation to plants, the commercial production of alcohol from agricultural products, digestion and dietary studies, etc. Prerequisites, Courses 5, 6 and 13. Seniors; laboratory, 10 hours. Credit, 5. Professor CHAMBERLAIN.

16. SPECIAL WORK IN PHYSICAL CHEMISTRY. — The field of agricultural chemistry offers many problems that have been attacked through the methods of physical chemistry; such, for example, are the hydrolysis of salts and of minerals and the absorption of salts and fertilizers by soils. Each student will select one line of work and follow it through the course, repeating some of the original work. Prerequisite, Course 15. Laboratory, 10 hours. Credit, 5.
Assistant Professor ANDERSON.

18. HISTORY OF CHEMISTRY. — An exposition of the development of chemical knowledge from the earliest times to the present. Although the entire history will be included, the larger portion of it will receive only brief

mention in order that the questions of vital interest in modern life and industry may be studied at greater length. Particular attention will be given to the questions of plant and animal industry. Chemists are strongly advised to take this course. Seniors; lectures, 2 hours. Credit, 2.

Professor WELLINGTON.

ENTOMOLOGY.

Professor FERNALD, Associate Professor CRAMPTON, Assistant Professor GATES, Mr. MARTIN, ————.

Elective Courses.

1. GENERAL AND ECONOMIC ENTOMOLOGY. — Course 1 comprises a general introduction to the study of insects, including studies on their structure as applied to their identification; the principles of classification; a systematic examination of the different groups and of the most important economic insects of each group, including their life histories and habits, recognition of their work as shown in the collections, and methods for their control. The most important insecticides and their preparation and application are also treated. Students electing Course 1 are expected to take Course 2. Juniors; 3 lecture periods. Credit, 3. Professor FERNALD.

2. GENERAL AND ECONOMIC ENTOMOLOGY. — A continuation of Course 1, with laboratory and field work on methods of collecting, preserving and studying insects and their work. Juniors; 2 laboratory or field periods. Credit, 3. Professor FERNALD.

3. ADVANCED ENTOMOLOGY. — This course is subdivided, the time spent on the various subdivisions differing somewhat according to the particular needs of those taking it; and it is to a large degree given in the form of individual instruction, special attention being paid to the pests attacking the particular crops in which the student is most interested. The student may specialize in fruit pests, market-garden pests, greenhouse pests, field crop pests, etc., to a large extent, in accordance with his plans for future work.

A. Morphology. — Careful studies of the structure of insects belonging to each of the larger and more important orders, together with lectures on the subject, followed by the identification of insects of each of these groups and the study of the collections, to teach the use of the analytical tables and of structural characters in the determination of insects.

B. Histology. — Lectures on the internal anatomy and histology of the various organs, with particular reference to those affected by the various insecticides.

C. Insecticides and Apparatus. — Lectures on the chemistry, preparation and application of the different insecticides, their merits and defects; tests for detecting adulterations; comparative tests of nozzles and other apparatus; and a study of other methods of insect control, together with laboratory work.

D. Coccidology. — Laboratory work on methods of preserving, mounting and identifying scale insects, particular attention being given to those of greatest economic importance.

E. Bibliography. — Studies of the various entomological publications and of the methods of finding the literature on any insect.

F. Special Studies. — In these studies the insects most closely related to the future occupation of the student will receive attention. The results of these studies are brought together in the form of an essay or thesis; this will include all the essentials of what is known of the life history, habits and injuries caused by each insect studied, together with methods of treatment, and a list of the best articles found in the course of the work. Comstock's "Manual for the Study of Insects" is used in the laboratory work. Seniors; prerequisite, Entomology 2; students electing Course 3 are expected to take Course 4; 1 1-hour lecture period and 3 2-hour laboratory or field periods. Credit, 4.

Professor Fernald, Associate Professor Crampton, Mr. Martin.

4. Advanced Entomology. — As stated in Course 3. Prerequisite, Course 3.

5. Forest Insects. — A study of insects injurious to forest trees and of methods for their control, with laboratory and field work on these insects, and a study of what has been published about them. Seniors; prerequisites, Entomology 1 and 2; 1 lecture and 2 2-hour laboratory or field exercises. Credit, 3. Professor Fernald.

8. Beekeeping. — This course comprises a general consideration of the biology of the honey bee and the elements of practical beekeeping. Some topics covered are: life history, general behavior and instincts, structure, products, relations of bees to plants, the honey flora. The course aims particularly to afford first-hand, practical experience with bees, to the end of enabling their proper maintenance for any purpose, horticultural, educational or apicultural. Bee diseases, a thorough understanding of which is fundamental, are emphasized. So far as possible the work is made individual in constructing materials and apparatus and in the manipulation of bees. Juniors; seniors may elect. Courses 1 and 2 form a desirable preparation; 2 lectures, 1 2-hour laboratory period. Credit, 3.

Assistant Professor Gates and Mr. ——.

10. Advanced Beekeeping. — This course deals with the advanced and special problems of the beekeeper. Besides considering those difficulties which at present confront the industry, subjects necessarily of limited treatment in the previous course are expanded for the development of particular technique and manipulation. Apiary management, including the principles of queen rearing, are practiced. The course should further qualify for apicultural instruction and inspection service, affording familiarity with the special literature and methods needed in investigation and research. The policy of individual instruction is continued in so far as practicable. Primarily for seniors, but juniors may elect; prerequisite, Course 8; 1 lecture, 1 2-hour laboratory period. Credit, 2.

Assistant Professor Gates and Mr. ——.

11. Evolution. — In order to demonstrate the universal scope and operation of the laws of evolution, the course includes a brief sketch of the probable origin and evolution of matter as viewed in the light of modern physical and

chemical research; the evolution of the solar system, leading to the formation of the earth; the changes in the earth, preparatory to the production of life; the physical and chemical basis of life; the probable steps in the formation of living matter, and the theories concerning it; the evolution of living things; the appearance of man; his future in the light of his past development; and the evolution of human institutions and ideas. Consideration is also given to the theories concerning the factors of evolution, the general problems of heredity and similar topics. The course closes with a brief discussion of the philosophical, moral and social aspects of the problems involved, and the influence of the idea of evolution upon modern thought. The lectures are supplemented by collateral reading; and a portion of the time is used for the purpose of demonstration, or discussion by the class. Seniors; juniors may elect. Two lecture periods. Credit, 2.

Associate Professor Crampton.

MATHEMATICS AND CIVIL ENGINEERING.

Professor Ostrander, Mr. Duncan, Mr. Machmer, Mr. Hazeltine.

Required Courses.

1. Higher Algebra. — A brief review of radicals, quadratic equations, ratio and proportion, and progressions; graphs, binomial theorem, undetermined coefficients, summation of series, continued fractions, determinants, permutations and combinations, logarithms, theory of equations. Reitz and Crathorne's "College Algebra." Freshmen; 3 hours a week. Credit, 3. Mr. Duncan, Mr. Machmer and Mr. Hazeltine.

2. Higher Algebra. — As stated under Course 1. Mr. Machmer.

3. Solid Geometry. — Theorems and exercises on the properties of straight lines and planes, dihedral and polyhedral angles, prisms, pyramids and regular solids; cylinders, cones and spheres; spherical triangles and the measurement of surfaces and solids. Wentworth and Smith's "Solid Geometry." Freshmen; required unless accepted for admission; 2 hours a week. Credit, 2. Mr. Duncan, Mr. Machmer and Mr. Hazeltine.

4. Plane Trigonometry (in Charge of Department of Physics). — The trigonometric functions as lines and ratios; proofs of the principal formulas, transformations; inverse functions, use of logarithms; the applications to the solution of right and oblique triangles; practical applications. Bowser's "Elements of Plane and Spherical Trigonometry." Freshmen; 3 hours. Credit, 3. Professor Hasbrouck and Assistant Professor Robbins.

Elective Courses.

5. Mensuration and Computation. — An elective, 3 hours per week, during the first semester, junior year. The course includes a review of methods of computation, with special emphasis on short and abbreviated processes, together with methods of checking computations and of forming close approximations; use of slide rule.

Also the graph, mensuration of plane and solid figures, weights and measures and elementary mechanism. Numerous practical problems are selected from such subjects as the following: the mathematics of wood working; rough lumber; general construction; forestry methods in heights of trees; pulleys, belts and speeds; power and its transmission; dairying; agronomy; computation of areas from simple measurements. Three hours. Credit, 3.
Mr. Machmer.

6. Plane Surveying. — The elements of the subject, including the adjustment and use of the usual instruments. Text-book and lectures. Sophomores; 6 hours a week. Credit, 3. Mr. Duncan and Mr. Hazeltine.

7. Analytic Geometry. — A discussion of the geometry of the line, the circle, of conic sections and of the higher plane curves. Fine and Thompson's "Coördinate Geometry." Prerequisites, Mathematics 1, 2, 3 and 4. Primarily for juniors; 3 hours a week. Credit, 3.
Professor Ostrander.

8. Differential and Integral Calculus. — A first course in the subject, with some of the more important applications. Nichol's "Differential and Integral Calculus." Prerequisites, Mathematics 1, 2, 3, 4 and 7. Primarily for juniors; 5 hours. Credit, 5. Professor Ostrander.

10. Roads and Railroads. — Topographic and higher surveying, highway construction, earthwork, pavements and railroad construction. Text-book and lectures; 6 hours. Credit, 5. Professor Ostrander.

11. Hydraulics and Sanitary Engineering. — Hydrostatics, theoretical hydraulics, orifices, weirs, pipes, conduits, water supply, hydraulic motors, sewers and sewage treatment. Text-book and lectures; 3 hours. Credit, 3.
Professor Ostrander.

12. Elementary Structures. — An elementary course in roofs and bridges. Text-book and lectures; 6 hours. [Not given in 1913–14.] Credit, 5. Professor Ostrander.

13. Materials of Construction, Foundations and Masonry Construction. — Text-book and lectures; 4 hours. [Not given in 1913–14.] Credit, 3. Professor Ostrander.

15. Applied Mechanics. — A course in applied mechanics, based on the calculus, with problems. Text-books and lectures. Prerequisites, Mathematics 7, 10; 3 hours. Credit, 3. Professor Ostrander.

PHYSICS.

Professor Hasbrouck, Assistant Professor Robbins.

[The fundamental and basic importance of the laws and phenomena of physics makes necessary no explanation of the introduction of this subject into the curriculum of an agricultural college. The logical development of the subject emphasizes the importance of physics as a science in itself. Special emphasis is laid, however, on the correlation of the principles studied with the sciences of agriculture, botany, chemistry, zoölogy, thus furnishing an extra tool by use of which the student's work in all the subjects may be more effective.]

Required Course.

1. General Physics. — General physics covers mechanics of solids, mechanics of fluids, wave motion and heat. These topics are chosen for the required work because they are regarded as the most fundamental of all, and there is no part of the work in physics more necessary for the student who plans to take up practical farming. Course given by text-book and lectures. Sophomores; 4 hours class-room work and 1 laboratory period. Credit, 5. Professor Hasbrouck and Assistant Professor Robbins.

Elective Courses.

2. General Physics. — Electricity and light. Text-book, lectures, recitations and laboratory work. Sophomores; 2 hours of class-room work and 1 laboratory period. Credit, 3. Assistant Professor Robbins.

3. Electricity, Heat and Light. — Three-hour lecture and laboratory course open to juniors and seniors; 1 lecture hour and 2 2-hour laboratory periods. Credit, 3. Assistant Professor Robbins.

4. Continuation of Course 3, open to juniors and seniors; 1 lecture hour and 2 2-hour laboratory periods. Credit, 3. Assistant Professor Robbins.

[Mathematics 4 (trigonometry) is, for convenience of grouping, listed under Mathematics, although in charge of the Department of Physics.]

VETERINARY SCIENCE.

Professor Paige, Associate Professor Gage.

[The courses in veterinary science have been arranged to meet the needs of students who propose following practical agriculture, and of prospective students of human and comparative medicine.]

Elective Courses.

First Semester.

1. Veterinary Hygiene and Stable Sanitation. — This course is intended to familiarize the student with the relation of water, food, air, light, ventilation, care of stables, disposal of excrement, individual hygiene, etc., to the prevention of disease in farm animals. Juniors and seniors; 3 hours. Credit, 3. Professor Paige.

3. Comparative (Veterinary) Anatomy. — The anatomy of the horse is studied in detail, and that of other farm animals compared with it where differences exist. This course is essential for those students wishing to elect Course 4. Juniors and seniors; 3 hours. Credit, 3. Professor Paige.

5. Essentials of General Pathology. — This course is planned to introduce the student to some of the essential anatomical, histological and general physiological phenomena essential to the understanding of some of the simple general pathological conditions found in domestic animals. Some of the common methods of diagnosis will be considered in the laboratory. The various chemical and biological reactions and tests will be presented from the standpoint of pure science, showing applications of chemistry and biology. The course will serve to liberally educate and stimulate in the student of agriculture the appreciation of some of the methods used in animal pathology for detecting and controlling some of the more common animal diseases. Lectures, demonstration and laboratory work. Juniors and seniors; 2 3-hour laboratory periods. Credit, 3. Associate Professor Gage.

7. Avian Pathology (Course in Poultry Diseases). — The object of this course is to present information concerning the common diseases of poultry, their etiology, diagnosis and prevention. The work will consist of a systematic study of the diseases of the alimentary tract, liver and abdominal region, followed by a study of the diseases of the respiratory system, circulation and kidneys. The important disease-producing external and internal parasites will be considered; also diseases of the skin and reproductive organs. Lectures and demonstrations. Juniors and seniors; 2 3-hour laboratory periods. Credit, 3. Associate Professor Gage.

Second Semester.

2. General Veterinary Pathology, Materia Medica and Therapeutics. — In this course such fundamental and general pathological conditions are studied as inflammation, fever, hypertrophy, atrophy, etc., a knowledge of which is essential in the diagnosis, prevention and treatment of disease. The course in Pathology is followed by one in Materia Medica and Therapeutics, dealing with the origin, preparation, pharmacology, pharmacy, administration and therapeutic use of the more common drugs. Poisonous plants and symptoms and treatment of plant poisoning are also considered. Juniors and seniors; 3 hours. Credit, 3. Professor Paige.

4. Theory and Practice of Veterinary Medicine; General, Special and Operative Surgery. — A course intended to familiarize the student with the various medical and surgical diseases of the different species of farm animals. Particular attention is given to diagnosis and first-aid treatment. The student is taught the technic of simple surgical operations that can with safety be performed by the stock owner. This course should be preceded by Course 3, and taken in conjunction with Course 2. Lectures, demonstrations and practice. Juniors and seniors; 3 hours. Credit, 3.
Professor Paige.

6. Essentials of General Animal Pathology. — This is a continuation of Course 5, and is devoted to a study of some of the common pathological conditions by means of prepared sections, the aim being to demonstrate to the student abnormal animal histological structures commonly observed when material from various cases of animal diseases is prepared for microscopical study. Some of the biological products used in protecting animals against disease will be considered. Juniors and seniors; 2 3-hour laboratory periods. Credit, 3. Associate Professor Gage.

ZOÖLOGY AND GEOLOGY.

Associate Professor GORDON, Mr. BLANCHARD.

ZOÖLOGY.

Required Course.

1. ELEMENTARY ZOÖLOGY. — This course presents the underlying principles of biology and the zoölogical part of an introductory course. Laboratory dissection and lectures. Sophomores; 1 lecture hour and 2 2-hour laboratory periods. Credit, 3.
Associate Professor GORDON and Mr. BLANCHARD.

Elective Courses.

3. INVERTEBRATE OR VERTEBRATE ZOÖLOGY. — These are separate courses running throughout the year. They are scheduled for the same hour. The student may elect one or the other, but not both in the same year. The course in invertebrate zoölogy is designed primarily for students who are planning to take up entomology, but is open to any one. The course in vertebrate zoölogy deals with comparative vertebrate anatomy and physiology and is designed for those who desire or require a knowledge of the comparative anatomy and physiology of vertebrated animals. Each course includes laboratory, textbook and lecture work. These courses are scheduled in the junior year, but are open to seniors; 1 lecture hour and 2 2-hour laboratory periods. Credit, 3. Hours by arrangement.
Associate Professor GORDON and Mr. BLANCHARD.

4. INVERTEBRATE AND VERTEBRATE ZOÖLOGY. — The continuation and completion of Course 3 of the first semester; 1 lecture hour and 2 2-hour laboratory periods. Credit, 3.
Associate Professor GORDON and Mr. BLANCHARD.

5. ADVANCED ZOÖLOGY.[1] — Elective work in advanced zoölogy is offered to seniors who are interested in zoölogy or who are looking forward to advanced work in any department of zoölogy or allied branches; 2 1-hour periods and 3 2-hour periods during the fall semester. Credit, 5. Hours by arrangement. Associate Professor GORDON and Mr. BLANCHARD.

6. ADVANCED ZOÖLOGY.[1] — This course may be a continuation of the work of the first semester or of separate character; 1 1-hour period and 2 2-hour periods during the spring semester. Credit, 3. Hours by arrangement.
Associate Professor GORDON and Mr. BLANCHARD.

GEOLOGY.

Elective Course.

2. ELEMENTARY GEOLOGY. — Rock-forming minerals; rock types; rock weathering; dynamical, structural and surface geology. Lectures, map and field work. Sophomores; 1 1-hour period and 2 2-hour periods. Credit, 3.
Associate Professor GORDON and Mr. BLANCHARD.

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[1] The work offered in Courses 5 and 6 may apply on a minor for the degrees of master of science or doctor of philosophy.

DIVISION OF THE HUMANITIES.

Professor SPRAGUE.

ECONOMICS AND SOCIOLOGY.

Professor SPRAGUE.

[The courses in Economics and Sociology are planned with the purpose of giving the student that knowledge and understanding of the important factors and problems in this field of study and life which every active citizen and educated man ought to have.]

Required Course.

1. POLITICAL ECONOMY. — An introductory course which takes up the study of the nature and scope of economics, the evolution and organization of the present economic system, and the fundamental principles of production, exchange and consumption. The class will study and discuss such topics as wealth, value, capital, interest, profits, wages and labor, tariffs, trusts, etc. Debates on current economic problems will be organized in the class. Text-book, library readings, lectures and discussions. Arranged primarily for juniors; open to seniors; 3 hours. Credit, 3. Professor SPRAGUE.

Elective Courses.

2. INDUSTRIAL PROBLEMS. — This is a course in the most important industrial problems of the day, covering the methods of organizations of labor and capital, systems of industrial remuneration, means of securing industrial peace, legal status of labor unions and their activities, protective legislation for workmen and employers, the problems of immigration, the sweated industries, prison labor, child labor and industrial education. Text-book, with collateral readings, lectures and discussions; 3 hours. Credit, 3.

Professor SPRAGUE.

4. ANTHROPOLOGY; THE HISTORY OF HUMAN CIVILIZATION. — The evolutionary origin and history of man; characteristics of primitive men, departure from the animal status, and the beginnings of civilization; development of industries, arts and sciences; the growth of languages, warfare, migrations and social institutions; a study of the powerful natural and human forces that have brought man from the early stages to modern conditions; characteristics of the leading races of the world. These topics will constitute the subject-matter of the course. Arranged for sophomores and juniors. Library readings, text-book and lectures; 3 hours. Credit, 3.

Professor SPRAGUE.

5. PUBLIC FINANCE, MONEY AND BANKING. — This course follows Economics 1. It will take up taxation and the various systems for collecting public revenue in Europe and America, with the problems involved; the history of money and the systems of banking and finance now in operation; the causes and problems of economic crises and depressions; the currency problems of the United States. For juniors and seniors. Readings, lectures and discussions; 3 hours. Credit, 3. Professor SPRAGUE.

7. Social Institutions and Social Problems. — This course is devoted to the study of the social institutions, such as the family, the church, State and property; and to such current social problems as divorce, race suicide, crime and prison reform, poverty and its relief. Considerable time is given to the study of eugenics in its social significance and possibilities. The correctional and charitable institutions of Massachusetts are studied in some detail. The later weeks of the term are devoted to a short introduction to sociological theory. Arranged especially for seniors; open to juniors by permission. Readings, lectures, discussions; 3 hours. Credit, 3.

Professor Sprague.

8. Modern Social Reform Movements. — The history of property and its vital issues in modern times; the socialistic systems, anarchy and communism; systems of workingmen's insurance in Europe and America, and other methods of relief from the chances of life; educational reforms, in process, to meet the demands of a new age, and legislative remedies for the evils of social change and maladjustment; the crisis of Christianity under modern capitalized industrialism. These topics indicate the nature of the subjects studied. This course is arranged to follow Economics 7; 3 hours. Credit, 3.

Professor Sprague.

HISTORY AND GOVERNMENT.

Associate Professor Eyerly, Mr. Holcomb.[1]

Elective Courses.

1. Elements of Political Science. — Nature and scope of political science; origin and evolution of the State; systems of government in the principal European States; organization and working of the national and of the State governments of the United States; relation of government to political parties and to public opinion; the functions of government as related to labor and commerce. Three hours. Credit, 3.

Associate Professor Eyerly.

2. Local Political Institutions. — A comparative study of the organization, functions and achievements of country and city groups, especially as these are concerned with such matters as taxation, finance, licenses, franchises, public ownership, highways, transportation and communication, water supply, fire protection, public lighting, markets, food inspection, garbage and sewage disposal, infectious diseases, housing conditions, police force, parks and playgrounds, libraries, schools, care of dependents. Three hours. Credit, 3.

Associate Professor Eyerly.

3. The History of New England. — In this course, New England is regarded as a unit. Although the history of agriculture and of rural life is treated with special fulness, ample attention is given to political, religious and ethical history. It is hoped that the student will not only be led to an intelligent understanding of present economic conditions, but will also be imbued with a progressive loyalty to the highest ideals of the New England of the past. Lectures and required reading; 3 hours. Credit, 3. Mr. Holcomb.

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[1] Mr. Holcomb resigned Nov. 1, 1913.

5. The History of Ideals. — This course treats history from the idealistic rather than from the economic point of view. It attempts to define the great ideals which have impelled some of the most important social, political, esthetic, scientific, ethical and religious movements of medieval and modern history, and to trace the causes of the success or failure of the movements to which these ideals have led. Christianity, including monasticism, modern Catholicism and Protestantism; medieval art and architecture; the modern scientific movement; and social and political democracy will be treated historically from this point of view. Lectures and reading; 3 hours. Credit, 3. Mr. Holcomb.

LANGUAGES AND LITERATURE.

Professor Mills.

LANGUAGES AND LITERATURE: ENGLISH, JOURNALISM AND PUBLIC SPEAKING.

Associate Professor Neal,[1] Professor Lewis, Assistant Professor Smith, Mr. Wattles, Mr. Prince, Miss Goessmann.

English.

Required Courses.

1, 2. Freshman English. — Composition; introduction to literature. Recitations, laboratory practice and lectures; theme writing; conferences. Text-book and laboratory manual, Neal's "Thought-building in Composition." Freshmen; 4 hours. Credit, 4.

Associate Professor Neal, Assistant Professor Smith, Mr. Wattles, Mr. Prince.

3, 4. Sophomore English. — A general reading course in English literature. Prerequisite, Courses 2 and 3 respectively; sophomores; 2 hours. Credit, 2. Professor Lewis and Miss Goessmann.

Elective Courses in English Language and Literature.

[The department does not plan to give in any one year all the elective courses here outlined, but as far as practicable to provide each instructor with at least one course in literature as a needed balance to his work in composition, at the same time providing opportunity for instructors to teach and students to study literature in its various periods and aspects.]

[7. Expository Writing. — The principles of exposition, with exercises in composition. Subjects will be largely found in current events and contemporary thought, and treated editorially. A foundation course in more advanced composition, primarily for juniors but open to seniors; advised for those who plan to take Course 8. Not given in 1913–14. Two hours, with a third hour at the option of the instructor. Credit, 2.

Mr. Wattles.]

[8. Expository Writing. — The principles of exposition with especial reference to technical writing, including the writing of bulletins; some atten-

[1] Absent on leave during first semester.

tion also to the more popular exposition of scientific facts. Primarily for juniors but open to seniors. First offered in 1912–13. Two hours, with a third hour at the option of the instructor. Credit, 2. Mr. WATTLES.]

[9,] 10. CULTURAL READING. — Outside individual reading courses, with reports and notebooks; examinations may be given if deemed advisable. Course 9 not offered in 1913–14. Credit, 1 hour. THE DEPARTMENT.

13, 14. ENGLISH WRITERS AND THOUGHT. — Studies, laboratory problems, readings, and reports in some period of English or American literature. Three hours. Credit, 3. Assistant Professor SMITH.

15. PROSE MASTERS OF THE NINETEENTH CENTURY. — A sympathetic study of the writings of Ruskin, Carlyle, Newman, Arnold and Stevenson. Junior and senior course; 3 hours. Credit, 3. Professor LEWIS.

[16. POETS OF THE VICTORIAN AGE; BROWNING, TENNYSON AND ARNOLD. — This course will deal especially with the ethical and religious ideals of these poets as expressed in their most serious poems. Not given in 1913–14. Junior and senior course; 3 hours. Credit, 3. Professor LEWIS.]

[17,] 18. ADVANCED LITERATURE. — The courses vary from year to year. They will usually provide opportunity either for intensive study of great writers or the study of the historical development or the structure and characteristics of literary types and practice in composition. Course 17 not given in 1913–14. Three hours. Credit, 3. Associate Professor NEAL.

JOURNALISM.

[The courses in journalism emphasize rural journalism. They aim to acquaint the student with the elementary problems and theory of journalism as a profession or vocation, and to exercise him, as far as conditions permit, in the commoner aspects of journalistic work, such as news-gathering, news-writing, desk-editing and editorial writing. By rural journalism is meant the application of journalistic principles in getting and suitably presenting material adapted to the non-urban rather than to the urban or metropolitan reader, so far as their interests are distinct. This includes agricultural journalism, but is by no means confined to that. Members of the classes supply, under the head "The Bay State Ruralist," a feature page for the "Springfield Sunday Union." Members of all classes may be required to turn in copy regularly for such disposition as the instructor may determine, and must have free time for covering stories. Students wishing to proceed beyond elementary study are urged to consult with the instructor before making their election in other subjects for the junior-senior years, in order that the most helpful program of work may be arranged.]

Elective Courses.

[1. INTRODUCTION TO JOURNALISM. — The foundation conceptions and aims of journalism; practice in the simple forms of journalistic writing. Prerequisite to all other work in journalism, and valuable also to students preparing for practical farming, agricultural or general science, rural education, etc., as a vocation. [See Course 2, for 1913–14.] Two hours, with a third hour at option of the instructor. Credit, 2. Associate Professor NEAL.]

2. Reporting. — News-gathering and news-writing. This includes the gathering and presentation of industrial and agricultural information, campus news or other stories, as may be directed. Courses 1 and 2 are the foundation courses in journalism. Students admitted to 2 who have not had 1 will be required to do extra work. In 1913–14, Course 1 will be given in semester 2 as Course 2; Course 2 not being given separately that year. Two hours, with a third hour at the option of the instructor. Credit, 2.

Associate Professor Neal.

[3,] 4. Journalistic Practice. — The gathering and preparation of material for publication. Prerequisite, Course 1 or its equivalent. Two hours, with a third hour at the option of the instructor. Credit, 2.

Associate Professor Neal.

[5,] 6. Advanced Journalistic Practice. — Informal; given only on application; students will be assigned work as editorial assistants or writers, or otherwise employed in some form of journalistic activity. Study of particular forms of journalistic writing, of special subjects and their journalistic presentation, of particular kinds of periodical, or of current topics may be directed, and the presentation of a thesis may be required. Hours to be arranged. Two hours. Credit, 1. Associate Professor Neal.

Public Speaking.

Required Courses.

1, 2. Freshman Public Speaking. — Freshman public speaking is required in either the first or the second semester at the option of the instructor. The course is concerned with the actual problems which confront the man who would speak convincingly and persuasively. Some attention is given to breath control and development of speaking voice, considerable attention to pronunciation and enunciation, and a large amount of attention to the preparation and delivery of extempore speeches. Text-book, Shurter's "Extempore Speaking," supplemented by lectures and discussions. Freshmen; in semester 1 or 2 as directed; 1 hour. Credit, 1. Mr. Prince.

8. Occasional Oratory. — Exercises for voice and gesture; a study of the elements of vocal expression and action; speeches on assigned topics; prescribed reading; the preparation and delivery of a formal oration or two. It is especially recommended for those who desire to enter the Flint contest. Two hours. Credit, 2. Assistant Professor Smith.

9. Debating. — Considerable time is given to the study of argumentation and brief-drawing. The class is divided into teams for the platform discussion of leading questions of the day. This course is designed to develop readiness in extempore speaking. It is recommended for those who desire to enter the inter-collegiate debates. Prerequisite, Course 3; 2 hours. Credit, 2.

Assistant Professor Smith.

LANGUAGES AND LITERATURE: GERMAN.

Assistant Professor Ashley, Mr. Julian.

Required Courses.

1. Elementary German. — Grammar and composition; the reading of short stories, poems, plays, etc. Especial attention is given to oral questioning and answering in German, and to translation of English into German. Required of those presenting French for entrance who do not continue that language and have not studied German. Arranged for Freshmen; open by permission to other students; 4 hours. Credit, 4. Mr. Julian.

2. Elementary German. — As stated under Course 1. Prerequisite, Course 1.

3. Intermediate German. — Rapid reading of selected works from Schiller, Goethe, Lessing and others; review of grammar and dictation in German; outside readings. Required of freshmen who present German for entrance and do not take French. Freshmen; open upon arrangement to other students; 4 hours. Credit, 4. Assistant Professor Ashley.

3A. Intermediate German. — Rapid reading of prose works, such as Sudermann's "Frau Sorge," and dramas, such as "Wilhelm Tell" and "Die Journalisten." Required of sophomores who took Courses 1 and 2 as freshmen. Mr. Julian.

4. Intermediate German. — As stated under Course 3. Prerequisite, Course 3.

4A. Intermediate German. — As stated under Course 3A. Open to students who have completed German 3A; 3 hours. Credit, 3.

5. Advanced German. — Literary study of the classicists, — Schiller's "Wallenstein," Lessing's "Nathan der Weise," Goethe's "Iphigenia," etc.; collateral readings in German and class-room reports. Prerequisite, Course 4. Sophomores; required of those who took German 3 and 4 as freshmen; open upon arrangement to other students; 3 hours. Credit, 3.
Assistant Professor Ashley.

Elective Courses.

6. Advanced German. — As stated under Course 5. Sophomores; open upon arrangement to other students. Prerequisite, Course 5; 3 hours. Credit, 3. Assistant Professor Ashley.

7. Scientific German. — Reading in German of modern magazine articles and works of a scientific nature. Different work assigned according to needs of individual students. Open to juniors who have completed Course 4A or more advanced work. Three hours. Credit, 3.
Assistant Professor Ashley.

8. Modern German. — As stated under Course 7.

9. Conversation and Composition. — Translating connected English into German. Reproducing outside readings in German orally in class; 1 hour. Credit, 1.

10. Scientific German. — As stated under Course 9.

11. German Literature. — Advanced language and literary study. Conducted entirely in German. Lectures on German literature and history; life, customs and travel in Germany. Collateral readings, including masterpieces of different epochs, such as "Niebelungenlied," Goethe's "Faust," and one modern typical drama. Prerequisite, Course 6 or 10.

Assistant Professor Ashley.

12. German Literature. — As stated under Course 11.

LANGUAGES AND LITERATURE: FRENCH.

Assistant Professor Mackimmie, Mr. Harmount.

Required Courses.

1, 2. Elementary French. — The essentials of grammar are rapidly taught, and will be followed by as much reading as is possible. This course is required of freshmen presenting German for entrance who do not continue that language and have not studied French; open upon arrangement to other students. Freshmen, 4 hours. Credit, 4. Mr. Harmount.

3. Intermediate French (third year). — Training for rapid reading; the reading of a number of short stories, novels and plays; composition; reports on collateral reading from periodicals and scientific texts in the library. Required of freshmen who present two years of French for entrance and do not take German, and of sophomores who take Courses 1 and 2 as freshmen; open upon arrangement to other students; 4 hours. Credit, 4.

Assistant Professor Mackimmie, Mr. Harmount.

4. Intermediate French. — As stated under Course 3, but not required of sophomores who take Courses 1 and 2 as freshmen. Prerequisite, Course 3. Assistant Professor Mackimmie.

5. Advanced French (fourth year). — A reading course; Balzac's "Eugenie Grandet" and "Le Père Goriot" and other masterpieces of the nineteenth century; Brunetière's "Honoré de Balzac" and Harper's "Masters of French Literature;" readings in the library and written reports. Required of sophomores who take Courses 3 and 4 as freshmen; open upon arrangement to other students. Prerequisite, Course 4; 3 hours. Credit, 3.

Assistant Professor Mackimmie, Mr. Harmount.

Elective Courses.

6. Advanced French (fourth year). — A general view of the history of French literature; Kastner and Atkins' "History of French Literature." Several plays of the great classical dramatists will be read. Individual conferences on outside reading selected by the student. Prerequisite, Course 5. Sophomores; open upon arrangement to other students; 3 hours. Credit, 3.

Assistant Professor Mackimmie.

7, 8. Scientific French. — This course is planned to meet the requirements of the individual student and aims to equip him with exact English equivalents for the French scientific terms in his particular science. Word lists of scientific terms will be required and also weekly readings and reports from scientific works in the subject in which he is majoring. Several scientific readers will be read. Three hours. Credit, 3. Mr. Harmount.

9, 10. Modern French Literature. — The outline is intended as a suggestion. The exact subject matter of the course will be determined when the men are enrolled. The object of this course is to give an introduction to recent movements in French literature. In the drama, readings from Augier, A. Dumas, fils, Delavigne; in the novel, from Flaubert, the de Goncourts, Zola; in criticism, from Taine, Renan, Sainte-Beuve; for the literary history of the period Lanson's "Histoire de la Litterature Française." Prerequisite, the required French. Juniors or seniors; 3 hours. Credit, 3.
Assistant Professor Mackimmie.

LANGUAGES AND LITERATURE: SPANISH.

Assistant Professor Mackimmie.

Elective Courses.

1. Elementary Spanish. — Grammar, with special drill in pronunciation; reading from a simple reader. Seniors or juniors; open upon arrangement to other students; 3 hours. Credit, 3.
Assistant Professor Mackimmie.

2. Modern Spanish Authors. — Reading from modern Spanish novel and drama. Prerequisites, Course 1. Seniors or juniors; open upon arrangement to other students; 3 hours. Credit, 3.
Assistant Professor Mackimmie.

LANGUAGES AND LITERATURE: MUSIC.

Assistant Professor Ashley.

Elective Courses.

1. History and Interpretation of Music. — History of music among the ancients; medieval and secular music; epoch of vocal counterpoint; development of monophony opera and oratorio; life and works of the greatest representatives of the classical school — Bach, Händel, Haydn, Gluck and Mozart. One hour. Credit, 1. Assistant Professor Ashley.

2. History and Interpretation of Music. — A continuation of Course 1. The Romantic school; Beethoven, Schubert, Weber, Mendelssohn, Schumann, Chopin, Berlioz and Liszt; Wagner and the opera. The Modern school and Modern composers. One hour. Credit, 1.
Assistant Professor Ashley.

DIVISION OF RURAL SOCIAL SCIENCE.

President Butterfield.

AGRICULTURAL ECONOMICS.

Associate Professor Cance, Mr. Baird.

Required Course.

2. Agricultural Industry and Resources. — A descriptive course dealing with agriculture as an industry and its relation to physiography, movement of population, supply of labor, commercial development, transportation, public authority and consumers' demand. The principal agricultural resources of the United States will be studied with reference to commercial importance, geographical distribution, present condition and means of increasing the value of the product and cheapening cost of production. Lectures, assigned readings, class topics and discussions. Sophomores; 3 hours. Credit, 3. Associate Professor Cance and Mr. Baird.

Elective Courses.

3. Elements of Agricultural Economics. — This course is designed to follow the required work in the elements of economics. It deals with the economic principles underlying the welfare and prosperity of the farmer and those institutions upon which his economic success depends; the economic elements in the production and distribution of agricultural wealth; means of exchange; determination of price; problems of land tenure and land values; taxation of farm property; and the maintenance of the economic status of the farmer. Lectures, text, readings, topics and field work; 3 hours. Credit, 3. Associate Professor Cance.

5. Historical and Comparative Agriculture. — Recommended to students in journalism or education. A general survey of agriculture, ancient and modern: feudal and early English husbandry; the later development of English agriculture; the course of agriculture in the United States, with special emphasis on the development of agriculture in New England. An attempt will be made to measure the influence of times, peoples and countries in producing different systems of agriculture, and to ascertain the causes now working to effect agricultural changes. Lectures, readings and library work. Seniors and juniors; open to other students upon arrangement; prerequisite, Course 3 or equivalent; 3 hours. Credit, 3.

Associate Professor Cance.

6. Co-operation in Agriculture. — The course treats of the history, principles and business relations of agricultural co-operation. (1) A survey of the development, methods and economic results of farmers' organizations and great co-operative movements; (2) the business organization of agriculture abroad, and the present aspects and tendencies in the United States; (3) the principles underlying successful co-operative endeavor among farmers,

and practical working plans for co-operative associations, with particular reference to credit and purchase and the marketing of perishable products. Lectures, text, assigned readings and practical exercises; 3 hours. Credit, 3.
Associate Professor CANCE.

7. THE AGRICULTURAL MARKET. — A study of the forces and conditions which determine the prices of farm products, and the mechanism, methods and problems concerned with transporting, storing and distributing them. Supply and demand, course of prices, transportation by freight, express and trolley, terminal facilities, the middleman system, speculation in agricultural products, protective legislation, the retail market, direct sales and the like are taken up. The characteristics and possibilities of the New England market are given special attention. Lectures, readings, assigned studies and field work. Juniors and seniors; 3 hours. Credit, 3.
Associate Professor CANCE.

8. PROBLEMS IN AGRICULTURAL ECONOMICS. — An advanced course for students desirous of studying more intensively some of the economic problems affecting the farmer. Some of these are: land problems, — land tenure, size of farms, causes affecting land values, private property in land, taxation of farm property; special problems, — cost of producing farm products, farm labor in New England, immigration, shifting of the rural population. Opportunity will be given, if practicable, for field work, and students will be encouraged to pursue lines of individual interest. Seniors and juniors; open upon approval to other students; 2 or 3 hours. Credit, 2 or 3.
Associate Professor CANCE.

9. SEMINAR. — Research in agricultural economics and history: New England agriculture to 1860. Library work and reports. If desirable some other topic may be substituted. Hours to be arranged. Credit, 1.
Associate Professor CANCE.

10. SEMINAR. — As stated in Course 9.

AGRICULTURAL EDUCATION.

Professor HART, Associate Professor MORTON.

Elective Courses.

1. MEANING OF EDUCATION (PSYCHOLOGY). — A study of the development, structure and function of the nervous system with reference to the sense organs; relation of mind to the nervous system; growth and nature of mental processes; the activities of the mind in the process of learning. Text-book, lectures, discussion and collateral readings and reports; 3 hours. Credit, 3.
Professor HART.

2. VOCATIONAL EDUCATION (HISTORY AND PHILOSOPHY). — A survey of educational and social movements with reference to their vocational aspects; the growth of educational institutions as influenced by science and industry. Lectures, collateral readings, reports and a thesis on some phase of industrial education; 3 hours. Credit, 3. Professor HART.

3. Rural School Problems. — This course is designed primarily for teachers. It consists of a study of the principles and methods of instruction, class management and the organization of subject-matter in agriculture for secondary schools; practice work in school and home gardens, instruction in elementary agriculture in grammar grades, demonstration lessons in class, and practice teaching in secondary schools where possible. One lecture period; 2 2-hour laboratory periods. Credit, 3. Professor Hart.

4. Continuation of Course 3, with similar periods and credit.
Professor Hart, Assistant Professor Morton.

5. Seminar in Education. — For students who have had Courses 1, 2 and 3, or an equivalent. Topics that may be taken up for rather exhaustive study are: rural school surveys and secondary school agriculture. Seniors and graduate students; 2 hours. Credit, 2. Professor Hart.

6. Seminar in Education. — As stated under Course 5.

Note. — Students who complete Courses 1, 2, 3 and 4 in this department and an approved major and minor in the following subjects may become candidates for a teachers' certificate: agriculture, biology, botany, chemistry, English, French, German, history, mathematics, physical geography, physics, physiology. See major in agricultural education for rules relating to teachers' certificates.

RURAL SOCIOLOGY.

Associate Professor Eyerly, President Butterfield, Professor Hart, Mr. Holcomb,[1] Mr. Strand.

Elective Courses.

1. The Rural Community. — A broad survey of the field of rural sociology, including such topics as the movements of the rural population, the social conditions and life of rural people, the influence of rural life, the description of the various social institutions of the rural community, an analysis of the fundamental problems of rural life, and the means of developing and redirecting the life of the rural community. Lectures, readings and essays on assigned topics; 3 hours. Credit, 3.
President Butterfield and Associate Professor Eyerly.

3. The Literature of Rural Life. — A critical and appreciative study of writers, both in prose and poetry, who have interpreted nature from the viewpoint of the lover of country life, and those who have idealized agriculture, horticulture and other rural pursuits, together with those who have upheld as an ideal the development of a rural environment in cities; 3 hours. Credit, 3. Mr. Holcomb.[1]

4. Rural Law. — The work of this course will cover such points as land titles, public roads, rights incident to ownership of live stock, contracts, commercial paper and distinctions between personal and real property. Text, written exercises, lectures, and class discussions; 1 hour. Credit, 1.
Professor Hart.

[1] Mr. Holcomb resigned Nov. 1, 1913.

8. The Social Conditions of the Rural People. — Composition of the rural population; nature, extent and causes of diseases and accidents; health agencies of control; extent and causes of delinquency and dependency; conditions of temperance, of sexual morality and family integrity; child labor; woman's work and position; relation of employer to employee; standard of living; size of family; cultural ideals; community consciousness and activity; standards of business conduct and of political ethics; 3 hours. Credit, 3.
Associate Professor Eyerly.

6. Sociological Aspects of Co-operation among Farmers. — An historical sketch of the origin, extent and success of co-operation among farmers in the various European countries and in the United States; personal qualities and social conditions necessary to successful co-operative endeavor; the various forms of co-operative organization viewed in their industrial, intellectual and moral aspects; the influence of co-operation on the farmer's individualism, conservatism, self-help, thrift, contentment and on agrarian legislation, scientific agriculture and farm labor; the relation of co-operation to neighborhood life, to community pride and loyalty, to further associated effort, to class stability, solidarity and status; the demand of co-operation for a new type of leadership; the relation of co-operation to socialism and the competitive system; 3 hours. Credit, 3. [Not given in 1913–14.]
Associate Professor Eyerly.

2. Rural Institutions. — A study of the organized agencies by which rural communities carry on their various forms of associated life; particularly a study of the ways by which the domestic, economic, cultural, religious and political institutions contribute to rural betterment. Special attention given to the rural family and the rural church; 3 hours. Credit, 3.
Associate Professor Eyerly.

5. The State and the Farmer. — A general survey of political organizations and movements among farmers in foreign countries and their influence in shaping agrarian legislation; the character, extent and results of foreign State aid to the farming class; political movements among farmers in the United States; "Granger" legislation; relation of the Department of Agriculture, State boards of agriculture, agricultural colleges and experiment stations, postal system, railway commissions, highway commissions, public health agencies, etc., to rural welfare; 3 hours. Credit, 3.
Associate Professor Eyerly.

9. The Social Psychology of Rural Life. — Characteristics of the rural mind; character of hereditary and environmental influences; nature and effects of face-to-face groups; psychological effects of isolation, relative security and freedom from strain; relation of contact with nature, of control over immediate environment, of family co-operation and of neighborhood life to self-control, self-expression, sympathy, service and leadership; nature and effects of fashion, conventionality and custom; character of discussion and public opinion, and their relation to class feeling and organization; relation of individualism, conservatism and homogeneity to crowd phenomena and progressive democracy; 3 hours. Credit, 3.
Associate Professor Eyerly.

10. Farmers' Organizations. — The history, purposes and achievements of the Grange, the Farmers' Union, farmers' clubs, village improvement associations, boys' clubs, etc.; the nature, scope, methods and history of local, State and national associations formed about some farm product or special farm interest, *e.g.*, dairying, horticulture, stock breeding, forestry; their influence on "better farming, better business, better living;" their influence in forming a class consciousness and in shaping legislation; need of federation; 3 hours. Credit, 3. Associate Professor Eyerly.

11. Sociological Aspects of Current Agricultural Questions. — Government conservation policy, roads, railways, trolleys, telephones, postal service, credit facilities, taxation, pure food laws, tenancy and ownership, intensive versus extensive farming, agricultural labor; 3 hours. Credit, 3.
Associate Professor Eyerly.

13. Seminar. Associate Professor Eyerly.

GENERAL DEPARTMENTS.

MILITARY SCIENCE AND TACTICS.

Captain Martin.

[The Department of Military Science and Tactics conducts its work in conjunction with the Department of Physical Education and Hygiene, in accordance with the following statement: —

All candidates for a degree in a four-years course must take for three years three full hours a week of physical training. This work must be under college supervision. At least two years of the work must be taken in the Department of Military Science and Tactics, in accordance with the requirements of the War Department; the rest is to be taken in the Department of Physical Education.

Under this arrangement, the practical (drill) courses in Military Science are given up to the Christmas recess and from the close of the spring recess to the end of the semester each year; the corresponding courses in Physical Education occupy the intervening time.

Under act of Congress (July 2, 1862), military instruction under a regular army officer is required in this college of all able-bodied male students. Men are excused from the exercises of this department only upon presentation of a certificate given by the college physician; minor disabilities which might bar enlistment are not considered. Students excused from military duty may be required to take equivalent work. The object of the instruction is to disseminate military knowledge in order that in emergency trained men may be found to command volunteer troops; but a further object is to give physical exercise, to teach obedience without detracting from self-respect, and to develop the bearing and courtesy that are as becoming in a citizen as in a soldier. Absences and other offences of military nature, and those of which the military instructor may take cognizance as affecting discipline, are dealt with by the commandant in accordance with the regulations of the department; but delinquencies in theoretical instruction not strictly military in their nature are dealt with in accordance with the rules of the faculty.

Cadets in the graduating class who have shown special aptitude for military service are reported to the Adjutant-General of the United States army and to the Adjutant-General of Massachusetts; in making appointments from civil life to the regular or volunteer army, preference is given to those who have been so reported. The names of the three most distinguished are published in the "Official Register of the United States Army." Assignments to the band are made by the military instructor. Practice in the band is credited in place of drill and theoretical instruction.

The required uniform is of khaki, costing about $18. It is worn by all cadets when on military duty, and may be worn at other times. The uniforms are procured through an authorized tailor. Students upon entering college are required to deposit $18 with the college treasurer to cover the cost of the uniform. The sale of old uniforms is prohibited, unless the consent of the military instructor be obtained.]

Required Courses.

1. Freshman Drill. — Practical instruction in infantry drill regulations through the school of the battalion in close and extended order; advance and rear guards; outposts; marches; ceremonies; guard duty. Upon the conduct and proficiency of this year depends the appointment of corporals for the ensuing year. Freshmen; first semester until Christmas recess; 3 hours. Credit, 1. Captain Martin.

2. Freshman Drill. — As stated under Course 1. Freshmen; second semester after spring recess; 3 hours. Credit, 1.

3. Sophomore Drill. — Practical instruction as before; pointing, aiming and sighting drills; litter drills, and first aid to the injured by detachment; target practice, in gallery and on the range. Corporals are appointed from this class. On their conduct and proficiency depends the appointment of sergeants in the next class. Sophomores; first semester until Christmas recess; 3 hours. Credit, 1. Captain Martin.

4. Sophomore Drill. — As stated under Course 3. Sophomores; second semester after spring recess; 3 hours. Credit, 1.

5. Sophomore Tactics. — Theoretical instruction in "Infantry Drill Regulations," to include the school of the company, "Manual of Guard Duty," "Small Arms Firing Regulations." Sophomores; 1 hour. Credit, 1.
Captain Martin.

6. Sophomore Tactics. — As stated under Course 5. Sophomores; 1 hour. Credit, 1.

7. Junior Drill. — Practical instruction as before, target practice, in gallery and on the range. Sergeants are appointed from this class. On their conduct and proficiency depends their selection as officers for the ensuing year. When necessary, officers will also be appointed from this class. Juniors; first semester until Christmas recess; 3 hours. Credit, 1.
Captain Martin.

8. Junior Drill. — As stated under Course 7. Juniors; second semester after spring recess; 3 hours. Credit, 1.

9. Junior Tactics. — Theoretical instruction in "Infantry Drill Regulations," to include the school of the battalion; advance and rear guards; outposts; marches and ceremonies; "Manual of Field Service Regulations;" preparation of reports; returns, muster-rolls, enlistment and discharge papers, rosters, requisitions, etc.; army regulations; lectures on military science. Juniors; 1 hour. Credit, 1. Captain Martin.

10. Junior Tactics. — As stated under Course 9. Juniors; 1 hour. Credit, 1.

Elective Courses.

11. Senior Drill. — Practical instruction as before; conduct of drills of lower classes. Officers will as a rule be selected from this class. Cadets electing Courses 11 and 12 must take the election for the year, and not later than the first Monday in June of their junior year. No cadet electing this course will after the commencement drill be permitted to change his election without the consent of the dean of the faculty and of the commandant. Seniors; first semester until Christmas recess; 3 hours. Credit, 1.
Captain Martin.

12. Senior Drill. — As stated under Course 11. Seniors; second semester after spring recess; 3 hours. Credit, 1.

PHYSICAL EDUCATION AND HYGIENE.

Assistant Professor HICKS, Mr. GORE, Mr. FITZMAURICE.

HYGIENE.

Required Course.

1. HYGIENE. — Lectures, reading, quizzes and a report on some assigned topic of personal hygiene or sanitation. Freshmen; 1 hour. Credit, 1.
Assistant Professor HICKS.

PHYSICAL EDUCATION.

[The Department of Physical Education conducts its work in physical training in conjunction with the Department of Military Science and Tactics, as explained in the note preceding the description of the courses in Military Science. All classified undergraduate students are given a physical examination upon entering.]

Required Courses.

1. ELEMENTARY GYMNASTICS. — Exercises, games and athletics; from January 1 to April 1, in connection with Course 2. Freshmen; 3 hours. Credit (given only for Course 2), 1. Mr. GORE and Mr. FITZMAURICE.

2. ELEMENTARY GYMNASTICS. — As stated under Course 1.

3. GRADED GYMNASTICS. — Exercises, games and athletics; from January 1 to April 1, in connection with Course 4. Sophomores; 3 hours. Credit (given only for Course 4), 1. Mr. GORE and Mr. FITZMAURICE.

4. GRADED GYMNASTICS. — As stated under Course 3.

5. GYMNASTICS. — Drills, games and athletics; from January 1 to April 1, in connection with Course 6. Juniors; 3 hours. Credit (given only for Course 6), 1. Mr. GORE and Mr. FITZMAURICE.

6. GYMNASTICS. — As stated under Course 5.

Elective Courses.

7. TRAINING COURSE. — History of Physical Education; supervision of indoor and outdoor athletic contests and games; athletic administration. Seniors; 3 hours. Credit, 1. Assistant Professor HICKS.

8. TRAINING COURSE. — As stated under Course 7.

The Graduate School.

The Graduate School.

Kenyon L. Butterfield, A.M., LL.D., President of the College.

Charles E. Marshall, Ph.D., Director of the Graduate School and Professor of Microbiology.

Graduate courses leading to the degrees of master of science and doctor of philosophy have been given for a number of years. Demands for these courses have now greatly increased, and in recognition of the benefits to be derived from a separate organization, a distinct graduate school has been established for the purpose of fitting graduates of this and other institutions for teaching in colleges, high schools and other public schools; for positions as government, State and experiment-station agriculturists, bacteriologists, botanists, chemists, entomologists, horticulturists and zoölogists; and for numerous other positions requiring a great degree of skill and scientific knowledge.

Admission.

Admission to the graduate school will be granted: —

1. To graduates of the Massachusetts Agricultural College.
2. To graduates of other institutions of good standing who have received a bachelor's degree substantially equivalent to that conferred by this college.

In case an applicant presents his diploma from an institution of good standing, but has not, as an undergraduate, taken as much of the subject he selects for his major as is required of undergraduates at the Massachusetts Agricultural College, he will be required to make up such parts of the undergraduate work in that subject as the professor in charge may consider necessary. He shall do this without credit toward his advanced degree.

Admission to the graduate school does not necessarily admit to candidacy for an advanced degree, — students holding a bachelor's degree being in some cases permitted to take graduate work without becoming candidates for higher degrees.

Applications for membership to the graduate school should be presented to the director of the school. Full statements of the applicant's previous training, of the graduate work desired, and of the amount and kind of work already done by him as an undergraduate should be submitted, — together with a statement whether the applicant desires to work for a degree.

Registration is required of all students taking graduate courses, the first registration being permitted only after the student has received an authorization card from the director.

Nature and Methods of Graduate Work.

Persons taking graduate work will find this quite different in its nature from undergraduate courses. A broad knowledge of two (or three) subjects is required, and the professors in charge of these may adopt any methods

which may seem desirable to secure this to the student. Lectures, laboratory and field work in various forms are utilized; but whatever the method chosen, the aim is to train the students in methods of original investigation and experiment, inductive reasoning and the ability to carry on independent research. In addition to the lectures, a large amount of outside reading is required, the object being to give a broad knowledge of all aspects of the subjects chosen, in addition to the complete knowledge of those portions involved in or directly related to the original investigation which is to result in the thesis. Originality and ability to lead in scientific research after completing graduate work, and the establishment of a broad and thorough foundation upon which these qualities must be based, are the objects aimed at; and any methods which promise to give these results may be made use of (varying according to the nature and personal equation of each student), the supervision being largely individual rather than collective.

Candidates for the degree of master of science are required to prosecute two subjects, one of which shall be designated as the major and the other as the minor. These subjects may not be selected in the same department.

Candidates for the degree of doctor of philosophy are required to prosecute three subjects, one of which shall be designated as the major, the others as minors. No two of these subjects may be taken in the same department.

Advanced students who are not candidates for degrees may, with the approval of the faculty of the school, take more than one subject in the same department.

A statement of the subjects chosen must in each case be submitted to the director of the school for approval by the necessary committee. The chosen subjects must bear an appropriate relation to each other.

A working knowledge of French and German is essential to successful graduate work, and students not having this will find it necessary to acquire it as soon as possible after entering.

A description of the equipment of the various departments is given under "General Information."

Theses.

A thesis is required of each candidate for an advanced degree. It must be on a topic belonging to the candidate's major subject, must show that its writer possesses the ability to carry on original research, and must be an actual contribution to knowledge.

Two copies of each thesis in its final form, ready for the printer, must be submitted to the director of the school before the candidate for the degree may take the required oral examination. One of the said copies, to contain all drawings, is to be retained as an official copy by the said director, and the other by the department in which the thesis was prepared. The candidate for the doctor's degree must be prepared to defend at the oral examination the views presented in his thesis. When printed, three copies of each thesis must be deposited with the director of the graduate school and three copies with the department in which the work was carried out.

All theses become the property of the department in which they are prepared.

Final Examinations.

For the degree of master of science, a final examination, which may be either written or oral, or both, is given upon the completion of each subject.

For the degree of doctor of philosophy, final examinations on the minors

taken are given upon the completion of the subjects. In the major subject, a written examination, if successfully passed, is followed by an oral examination in the presence of the faculty of the school.

Degrees Conferred.

The degree of master of science is conferred upon graduate students who have met the following requirements: —

1. The devotion of at least one year and a half to the prosecution of study in two subjects of study and research, not less than one full college year of which must be in residence.
2. The devotion of twenty hours each week to the chief or major subject, and of from twelve to sixteen hours per week to the minor subject.
3. The preparation of a thesis in the major subject, constituting an actual contribution to knowledge, and accompanied by drawings if necessary.
4. The passing of final examinations, in both major and minor subjects, to the satisfaction of the professors in charge.
5. The payment of all fees and college expenses required.

The degree of doctor of philosophy is conferred upon graduate students who have met the following requirements: —

1. The devotion of at least three years to the prosecution of three subjects of study and research in residence at the college.
2. The devotion of twenty hours each week to the chief or major subject during the entire period, and of from twelve to sixteen hours per week for a year and a half to each minor subject.
3. The preparation of a thesis, in the major subject, constituting an actual contribution to knowledge, and accompanied by drawings if necessary.
4. The passing of final examinations, in both the major and minor subjects, to the satisfaction of the professors in charge.
5. The payment of all fees and college expenses required.

The fee for the degree of master of science is $10, and for the degree of doctor of philosophy, $25.

Courses for Degree of Master of Science.

Available either as major or minor subjects for the degree of master of science: —

Agriculture.	Horticulture.
Botany.	Mathematics and physics.
Chemistry.	Veterinary science.
Entomology.	Zoölogy (minor only).

Courses for the Degree of Doctor of Philosophy.

Available for a major subject for the degree of doctor of philosophy: —

Botany.	Entomology.
Chemistry.	Horticulture.

Available for a minor subject for the degree of doctor of philosophy: —

Agriculture.	Entomology.
Botany.	Horticulture.
Chemistry.	Zoölogy.

General Outline of Courses for the Doctorate.

Major Courses.

Botany. — The following subjects in botany may be studied: —

(*a*) Vegetable physiology.

(*b*) Vegetable pathology.

(*c*) Ecology.

(*d*) History of Botany.

In the graduate course in botany special attention is given to such subjects as plant physiology and pathology, ecology and the history of botany, etc. These subjects are pursued to a greater or less extent, as the previous training of the student and the nature of the original problem undertaken may determine. The object of the course is to give the student a technical training in botany to develop the spirit of research and to lay a broad foundation in the subject. (As a supplement to this course the student will do well to take, in addition to his prescribed minor work, a brief course in the history of philosophy and psychology.) Extensive reading of botanical literature, both general and specific, is required in certain subjects, and weekly lectures are given, together with occasional seminars, in which various new problems of botanical science are considered. A thesis dealing with some economic problem in plant physiology or pathology, or in both, and containing a distinct contribution to knowledge, is required.

Chemistry. — The department is prepared to offer advanced courses in the following branches of chemistry, particularly as applied to agriculture: —

(*a*) Inorganic chemistry.

(*b*) Organic chemistry.

(*c*) Physiological chemistry.

(*d*) Physical chemistry.

(*e*) Analytical chemistry.

Here follows a statement of courses which may be selected by any one properly qualified, and particularly by those who are desirous of doing work for advanced degrees: —

Course A. Research in industrial problems applied to agriculture.

Associate Professor Peters.

Course B. Research in physico-agricultural chemistry. Prerequisite, Course 15 or its equivalent. Assistant Professor Anderson.

Course C. Advanced analytical chemistry. Research work in connection with the study of methods of analysis of fertilizers, cattle feeds, dairy products, soils, insecticides and sugars. Recent and original methods will be applied to a study of the composition of agricultural products.

Professor Wellington or Associate Professor Peters.

Course D. Advanced organic chemistry. Special topics in advanced organic chemistry will be considered, both by lectures and in the laboratory. These will include such subjects as constitution and properties of carbohydrates, proteins and fats, uric acid and related compounds, and alkaloids;

also such purely chemical phenomena as isomerism, tautomerism and optical rotation. The reading will include "The Monographs on Biochemistry," Cohen, Schorlemmer and Lachman. Professor Chamberlain.

Course E. Advanced topics in physiological agricultural chemistry will be studied especially in the laboratory, including digestion, metabolism and nutrition, dietetics, feeding rations, enzymatic action and isolation of enzymes. Required reading will be followed in Abderhalden, Lusk, Hammersten, Stiles, Armsby and Euhler. Professor Chamberlain.

Students for the advanced degrees of master of science and doctor of philosophy will be given a special outline of work, and will also be assigned a subject for an original thesis by the professor in charge of the work, all of which must be completed to the satisfaction of the chemical staff and particularly of the professor under whom the work is done. Students not working for a degree may take special work along agricultural chemical lines. Information may be obtained by consulting the chemical staff.

Entomology. — I. For the degree of doctor of philosophy as a major: Some knowledge of all the divisions of this subject is essential for the professional entomologist, though a large part of his time will be devoted only to certain portions. To insure some familiarity with all these divisions, lectures, laboratory work, field training or required reading are given in each of the following topics: —

(*a*) *Morphology.* — Embryology; life history and transformations; histology; phylogeny and the relation of insects to other arthropods; hermaphroditism; hybrids; parthenogenesis; pedogenesis; heterogeny; chemistry of colors of insects; luminosity; deformities of insects; variation; duration of life.

(*b*) *Ecology.* — Dimorphism; polymorphism; warning coloration; mimicry; insect architecture; fertilization of plants by insects; instincts of insects; insect products of value to man; geographical distribution in the different faunal regions; methods of distribution; insect migration; geological history of insects; insects as disseminators of disease; enemies of insects, vegetable and animal, including parasites.

(*c*) *Economic Entomology.* — General principles; insecticides; apparatus; special cases; photographs of insects and their work; methods of drawing for illustrations; field work on insects and study of life histories; legislation concerning insects.

(*d*) *Systematic Entomology.* — History of entomology, including classifications and the principles of classification; laws governing nomenclature; literature, how to find and use it; indexing literature; number of insects in collections and in existence (estimated); lives of prominent entomologists; methods of collecting, preparing, preserving and shipping insects; important collections of insects.

(*e*) *Seminar.* — A monthly meeting of graduates, at which reports on current literature are presented and various entomological topics of importance are discussed.

(*f*) *Required Readings.* — The best article on the various topics named above and on the different orders of insects, to cover from fifteen thousand to

twenty thousand pages of English, French and German, the candidate to be examined at the close of his course on this with his other work.

(*g*) *Thesis.* — A thesis, illustrated with drawings, consisting of the results of original investigation upon one or several topics, and constituting a distinct contribution to knowledge, must be completed before the final examinations are taken.

II. For the degree of doctor of philosophy as a minor, and for the degree of master of science either as a major or minor: Such portions of the course outlined above as seem most appropriate to their other subjects are given to students taking entomology as a minor.

Horticulture. — Graduate work is offered in various lines of horticulture. For the most part this is divided into the different departments which now constitute the college Division of Horticulture, and which are as follows: Pomology, Floriculture, Landscape Gardening, Forestry and Market Gardening. For work in these lines application should be made direct to the heads of the several departments.

Besides this work, however, opportunity is offered for graduate study in General Horticulture, including topics from the several organized departments mentioned, and also questions relating to plant breeding, general evolution, propagation, manufacture of horticultural products, etc. This general work is under the direction of Prof. F. A. Waugh, head of the Division of Horticulture.

Zoölogy. — Courses in zoölogy are available as a minor for the degree of master of science, and as a minor for the degree of doctor of philosophy. The nature of the work varies according to circumstances, and may be intensive in a special field, or of a somewhat more general character, depending on the student's previous acquaintance with general zoölogical science.

The time devoted to zoölogy as a minor for either of the above-named degrees may vary from 12 to 16 hours per week, pursued for a year and a half.

Notes.

1. The graduate staff reserves the privilege of recommending and allowing courses in other institutions as a part of residence instruction. Such supervision will be exercised by the graduate staff and credit granted as are essential to the highest standards of efficiency.

2. All time statements refer to the minimum time recognized. It will be readily understood that diligence, seriousness of purpose, capacity, proficiency, and effectiveness cannot be measured by a definite number of hours.

3. A course may be outlined for a student by any department, subject to the approval of the graduate staff. The courses offered above, however, constitute the established courses at present.

The Short Courses

and

The Extension Service.

THE SHORT COURSES AND THE EXTENSION SERVICE.

THE EXTENSION SERVICE.

Through its Extension Service, the Massachusetts Agricultural College attempts to make every department of the institution a contributing factor toward developing the agriculture and country life of the Commonwealth. The work of the Extension Service divides itself quite naturally into the Short Courses given at the college and the various activities of an educational nature which are carried on all over the State.

Under the usual definition of extension activities, Short Courses are not strictly extension projects. They are rather a part of the academic work of the institution. For the sake of administrative efficiency it has seemed best to place them in charge of the director of the Extension Service in so far as organization and direction are necessary. An effort is made through these courses to bring to the college, for a few days or a few weeks, as many people as can possibly be reached in this way. In the main, the instruction in the Short Courses is given by the regular teaching force of the college, the same laboratories and equipment being used for this work as in the regular college work.

The Extension Service proper comprises various methods for the dissemination of agricultural information to the people of the Commonwealth who are interested in agriculture and country life, but who cannot come to the college for even a short time. The object of the Extension Service is to make the college as useful to the people of the Commonwealth as possible.

SHORT COURSES GIVEN AT THE COLLEGE.

A. Winter School.
   1. Ten Weeks' Courses.
   2. Apple Packing School.
   3. Farmers' Week.
   4. Beekeepers' Course and Convention.

B. Summer School.
   1. Summer School of Agriculture and Country Life.
   2. School of Rural Social Service.
   3. Conference on Rural Community Planning.
   4. Boys' Agricultural Camp.
   5. Poultry Convention.

C. Miscellaneous Short Courses.
   1. The School for Tree Wardens.
   2. Short Courses for Other Groups.
   3. Special Days for Foreigners.
   4. Meetings of Organizations at the College.

EXPENSES OF THE SHORT COURSES. — The expense of attending any of the Short Courses is approximately as follows: —

Registration fee (Ten Weeks' Course, Apple Packing School, Summer School),	$5
Furnished rooms in private houses (per week),	$1.50-$3
Board at college dining hall, per week,	$4
Board with private families, per week,	$5-$6

A lunch counter is operated in connection with the college dining hall. Meals may be obtained there *à la carte* at very reasonable prices.

Students in each of the dairy courses must provide themselves with two white wash suits and a white cap for use in the practical dairy work. The cost in Amherst is about $1.25 for suit and cap.

Requirements for Admission to Short Courses. — No entrance examinations are required, but students are advised to review their school work in English and arithmetic. Practical experience in farm, garden, orchard or greenhouse work is an advantage. The courses are open to both men and women.

Students must be at least eighteen years of age and must furnish satisfactory evidence of good moral character. References are required and these are investigated before applicants are accepted.

A. Winter School, 1914.

1. Outline of the Ten Weeks' Courses (January 6 to March 13, inclusive). — The following courses are to be given: —

1. Soil Fertility. Associate Professor Haskell. Three lectures a week for ten weeks.
2. Field Crops. Mr. E. M. McDonald, Instructor in Agronomy. Three lectures a week for ten weeks.
3. Types and Breeds of Live Stock. Associate Professor McLean. Three lectures and two two-hour judging periods a week for ten weeks.
4. Live Stock Feeding. (Instructor to be announced.) Three lectures a week for ten weeks.
5. Live Stock Management. Mr. E. L. Quaife, Instructor in Animal Husbandry. One two-hour laboratory period each week.
6. Animal Breeding. Associate Professor McLean. One lecture and one two-hour laboratory period each week.
7. Dairying. Professor Lockwood, Mr. Coons and assistants. Five one-hour and two two-hour periods and two three-hour periods each week.
8. Dairy Bacteriology. Professor Marshall. Two lectures each week.
9. Animal Diseases and Stable Sanitation. Professor Paige. Two lectures each week.
10. Poultry. Professor Graham. Five lectures each week.
11. Fruit Growing. Professor Sears. Five lectures each week.
12. Market Gardening. Mr. B. C. Georgia, Instructor in Market Gardening. Three lectures each week.
13. Landscape Gardening. Assistant Professor Harrison. Two two-hour exercises each week.
14. Floriculture. Mr. E. J. Canning, Temporary Instructor. Five lectures and one field trip each week.
15. Forestry. Professor Clark. One lecture each week.
16. Botany. Mr. F. A. McLaughlin, Assistant in Botany. Two lectures each week.
17. Entomology. Professor Fernald. Three lectures each week.
18. New England Rural Life. Two lectures each week.
19. Farm Accounts. Professor Foord. One two-hour exercise each week.
20. Mechanics. Professor Lockwood and Mr. Schroyer. One two-hour exercise each week.
21. Rural Sanitary Science. Professor Marshall. Two lectures each week.
22. Beekeeping. Assistant Professor Gates and Mr. Byard. Three lectures and one laboratory period each week.
23. Rural Improvement. Professor Waugh. Two lectures each week.
24. Marketing Farm Products. Associate Professor Cance. One lecture each week.

2. Apple Packing School. — The work of this school, which is conducted by the department of pomology, is of a practical nature and includes both box and barrel packing. Persons taking the course will become familiar with the various types of packs and will receive sufficient practice to enable them to do good commercial packing.

The work in packing is supplemented by lectures on phases of commercial orcharding, such as planting, varieties, spraying, pruning, harvesting and marketing.

A fee of $5 to help pay for fruit and other materials used is charged for this course.

3. Farmers' Week. — In order to reach those who cannot come to the college for a longer time, this very practical course, four days in length, is given each year. The regular college equipment is used, and work of the regular faculty is supplemented by lectures and demonstrations by eminent men.

The work is divided into four sections: (1) General agriculture and farm management; (2) dairying, animal husbandry and poultry; (3) horticulture, including fruit growing, market gardening, floriculture and forestry; (4) women's section, including home economics, household management and so forth.

These sections take up the time from early morning until late afternoon. Prominent men are engaged for the evening lectures. Fruit, corn, dairy and poultry shows and other exhibits are among the leading features. No fee is charged. The date of the 1914 Farmers' Week is March 16 to March 20, inclusive.

4. Beekeepers' Course. — In the last few years a complete apiary and equipment has been brought together at the college, under the direction and management of Dr. Burton N. Gates. This equipment furnishes the best of facilities for the teaching of beekeeping and allied subjects. A conference of beekeepers, with extensive exhibits of beekeepers' supplies and apparatus, is held annually at the close of each short course.

The courses offered are: —

1. Practical Phases of Beekeeping. Assistant Professor Gates.
2. Crops for Honey Bees. Dr. Brooks.
3. Relation of Bees to the Pollination of Plants. Professor Stone.
4. Origin and Evolution of the Honey Bee. Professor Fernald.
5. Bees and Beekeepers' Supplies. Professor Paige.

The features of the convention are lectures, demonstrations by authorities of national reputation, as well as exhibits of inventors, manufacturers, supply merchants and queen rearers. A special invitation is extended to all beekeepers to display and demonstrate inventions, implements or methods. If table space is desired or special equipment is to be prepared, notice should be sent to Dr. Burton N. Gates, Amherst, Mass., at least two or three weeks before the convention. The college provides covered tables for the exhibits.

B. Summer Schools.

1. The Summer School of Agriculture and Country Life. — The Summer School of the Massachusetts Agricultural College will open June 30, 1914, for a term of five weeks. This will be the sixth session of this summer school, those of previous years having been highly successful. The experience of these five years will aid in making material improvements in the session of 1914.

The work of the summer school was designed originally for school-teachers, and the attendance has been largely of that class. Special attention will be

given to the needs of teachers again this year. It has been found, however, that there are many persons who seek a general knowledge of theoretical and practical agriculture, and who can come to the college conveniently during the summer season. Extended courses will be offered for the benefit of such persons also.

The formal instruction in the summer school is given in definite courses herein described. From these each pupil may elect courses of not less than 10 nor more than 15 exercises a week, unless a larger or smaller amount of work is allowed by the director. These courses include a large amount of field work, observation trips, outdoor exercises and laboratory experiments.

Besides these, general field exercises will be arranged for one afternoon of each week. These will be on topics of interest to all. Excursions will be arranged for every Wednesday afternoon, and more extended excursions for the whole school will be planned for every Saturday. The excursions will be in charge of an instructor as heretofore. In the past they have proved a very enjoyable feature of the work.

Round table and special discussions will be arranged by various instructors as their courses require. A conference of rural social workers and educators of New England will be held July 2 to July 31. An outline of the conference will be found in another part of this bulletin.

A course of evening lectures on popular topics relating to the work of the school will be a feature of the general program. Several able lecturers have already been engaged for this course. Like everything else connected with the summer school, this lecture course is entirely free to all students.

Those who expect to attend should register as early as possible. *Registration fee for the summer school is $5, payable at the time application is made. Registration fee for clergymen attending the courses and conferences given especially for them is $1.* No other tuition is charged. These fees should accompany application blanks and should be made payable to the director of the summer school or the college treasurer.

A bulletin describing the Summer School is issued in March each year.

Faculty and Courses. — The faculty and courses given in the 1913 School were as follows: —

Kenyon L. Butterfield, LL.D. President of the College. Head of the Division of Rural Social Science.

William D. Hurd, M.Agr. Director of the Extension Service.

Marion S. Borden, B.S. Assistant in Home Economics.

Robert H. Bogue, B.Sc. Assistant in Chemistry.

Joseph Chamberlain, Ph.D. Associate Professor of Organic and Agricultural Chemistry.

William D. Clark, M.F. Professor of Forestry.

Laura Comstock. Extension Professor of Home Economics.

Samuel Coons. Instructor in Buttermaking.

Guy C. Crampton, Ph.D. Associate Professor of Entomology.

Burton N. Gates, Ph.D. Assistant Professor of Beekeeping.

B. C. Georgia, B.Sc. Instructor in Market Gardening.

Harold M. Gore, B. Sc. Assistant in Boys' Camp.

John C. Graham, B.Sc. Agr. Associate Professor of Poultry Husbandry.

Charles R. Green, B.Agr. Librarian.

F. Josephine Hall, A.M. Adviser for Women, Waltham, Mass.

William R. Hart, A.M. Professor of Agricultural Education.

Sidney B. Haskell, B.Sc. Associate Professor of Agronomy.

Curry S. Hicks, B.Sc. Assistant Professor of Physical Education and Hygiene.

George S. Holcomb, A.B., S.T.B. Lecturer in History.

William P. B. Lockwood, B.Sc. Agr. Associate Professor of Dairying.

Frederick A. McLaughlin, B.Sc. Assistant in Botany.
John A. McLean, B.Sc. Agr. Associate Professor of Animal Husbandry.
C. J. Maynard. Author and Lecturer on Bird Life, West Newton, Mass.
Orion A. Morton. Extension Professor of Agricultural Education.
E. L. Morgan, A.M. Community Field Agent.
A. Vincent Osmun, M.Sc. Assistant Professor of Botany.
Charles A. Peters, Ph.D. Associate Professor of Inorganic and Soil Chemistry.
Laura Post. Assistant in Physical Education, Wellesley College, Wellesley, Mass.
Edward Tallmadge Root. Secretary of the Federation of Churches of Massachusetts and Rhode Island, Boston.
Frederick W. Ried. Director of Practical Arts, State Normal and Training Schools, Framingham, Mass.
John A. Scheuerle. Formerly Pastor of County Church, Hartford, Vt.
Fred C. Sears, M.Sc. Professor of Pomology.
Robert J. Sprague, Ph.D. Head of Division of the Humanities and Professor of Economics and Sociology.
George E. Stone, Ph.D. Professor of Botany.
Frank A. Waugh, M.Sc. Head of Division of Horticulture and Professor of Landscape Gardening.
Edward A. White, B.S. Professor of Floriculture.

2. The School of Rural Social Service. — For the sixth season the Massachusetts Agricultural College offers a School of Rural Social Service, in connection with the usual Summer School of Agriculture and Country Life.

The social service spirit is abroad all over this country, and men are turning their attention to these subjects as never before. The courses offered this summer will give instruction, furnish information and direct the attention of those interested more particularly, to the rural field, which has as yet received little systematic study when compared with that which has been given city conditions.

This year more of a feature will be made of the group of courses given especially for those who might be classed as Rural Social Workers. These courses are intended for clergymen, teachers, librarians, town officers, grange workers and others who devote a considerable portion of their time to problems of community development. Courses 30 to 36, inclusive, as given in the summer school, are designed for the needs of these persons. All other courses given during this period are also open to those who register.

From all of these courses a group of studies can be arranged which will present the rural problem from several standpoints, and will serve to show the relationships of the workers in the different lines to their respective fields and to the larger community problems which are constantly being presented to them.

3. The Conference on Rural Community Planning. — This conference is held as a closing feature of the summer school each year. In it the larger problems of New England community development are freely discussed. The following organizations co-operate with the college in providing the programs: the Massachusetts Federation of Churches, the State Board of Education, the Free Public Library Commission, the Massachusetts Civic League, the State Board of Health, the County Work of the Y. M. C. A., the New England Home Economics Association and the Bureau of Statistics.

Section meetings of these groups are held each forenoon, a general round-table discussion is held each afternoon, and lectures are delivered each evening by persons prominent in social and educational work. Many small group conferences are also arranged.

Extensive exhibits showing in a graphic way what organizations and com-

munities are doing along welfare lines are arranged at the time of the conference.

The conference usually lasts four days, coming the last of July and first of August. A full program is published about June 1. There are no registration or other fees.

4. Boys' Agricultural Camp. — This camp is arranged in order that boys from rural districts and small towns may receive some instruction in agriculture and clean, wholesome sports, and that they may have impressed upon them their responsibilities as coming members of society. The daily program consists of camp duty, flag raising, agricultural lessons, talks on hygiene, good citizenship, and so forth, play and recreation, instruction in handicrafts, photography, evening camp fires and lectures by men prominent in boys' work. A small fee is charged to help defray the cost of maintaining the camp.

5. Poultry Convention. — In order to give a large number of poultrymen, who cannot come to the college for a longer time, practical instruction in modern methods of breeding, feeding, poultry-house construction, operation of incubators and brooders, selecting and judging poultry for utility and for show, marketing poultry products, and so forth, — a convention lasting nearly a week is held each summer. The date of the 1914 meeting is from July 22 to July 24, inclusive.

C. Miscellaneous Short Courses.

1. The School for Tree Wardens. — This course is given in co-operation with the State Forester and the Massachusetts Forestry Association, to give tree wardens and city foresters instruction in the planting, care and preservation of trees, forestry practices, spraying, pruning, civic improvement, duties of tree wardens, and so forth. The 1914 school will be held from March 24 to 27, inclusive. No registration fees are charged. The cost of room and board is low.

2. Short Courses for Other Groups. — Plans are now under way to provide short courses at Amherst, lasting four or five days, for fertilizer agents, feed agents and dealers, milk inspectors, seed dealers and any other groups that may desire such instruction. Information concerning these may be obtained by writing the Extension Service.

3. Special Days for Foreigners. — Each year there are provided at the college special days for foreigners, especially the Polish farmers who have come into the Connecticut valley in large numbers. Instruction is given in the crops and animals in which these people are most interested, soil management, co-operation, the need of their becoming good American citizens, Polish history, and so forth. Similar work will gladly be arranged at the college, or in different sections of the State, for other nationalities.

4. Meetings of Organizations at the College. — It is customary for the various State organizations of fruit growers, poultrymen, breeders' associations, and so forth, to meet for conventions and picnics at the college. Such meetings are welcomed by the college authorities, and organizations are cordially invited to meet at the college. The Extension Service will provide facilities for seeing the college grounds, and help arrange programs and other forms of entertainment.

Itinerant Instruction arranged at the College but given throughout the State.

1. Correspondence Courses. — The correspondence courses are offered by the college in response to calls from all sections of the State from people who desire agricultural information, but who cannot come to the college for it. The courses are designed to meet the needs of farmers, dairymen, stock breeders, fruit growers, market gardeners, floriculturists and teachers in elementary schools, high schools, academies or normal schools.

Since agricultural science and practice are changing so rapidly, it is the purpose to give a summary of the latest information on the subjects treated, yet in such language that any who pursue the study can readily understand the work. Additional courses, covering other subjects, will be added from year to year.

Method of Conducting Correspondence Work. — While a large number of books have been written on various agricultural subjects, very few of them are especially adapted to the correspondence course work. For this reason the courses are conducted principally by specially prepared lessons. The subject-matter partakes somewhat of the lectures that are given in the college classes. It is recommended that the student purchase whenever possible one or two books to read along with the course. Other books are recommended for collateral reading and these can be obtained oftentimes from the local libraries.

The courses are especially recommended to the Y. M. C. A. and to granges and other farmers' clubs for study. It is to be hoped grange lecturers, club secretaries and other interested persons will organize study classes. If the size of the class or the interest which the members take in the subject is sufficient, a representative of the college is sent to the class from time to time to discuss the work and offer suggestions. Below are the courses being given in 1914: —

1. Soils and Soil Fertility. Associate Professor Haskell.
2. Manures, Fertilizers and Soil Amendments. Associate Professor Haskell.
3. Field Crops. Associate Professor Haskell.
4. Farm Dairying. Professor Lockwood.
5. Fruit Growing. Professor Sears and Mr. Rees.
6. Market Gardening. Conducted by Mr. B. C. Georgia.
7. Animal Feeding. Mr. Story.
8. Floriculture. Conducted by Mr. Canning.
9. Farm Accounts. Professor Foord.
10. Entomology. Professor Fernald.
11. Pedagogy of Agriculture. Professor Hart.
12. Beekeeping. Assistant Professor Gates.
13. Forestry. Professor Clark.
14. Shade Tree Management. Professor Stone.
15. Gardening and Elementary Agriculture. Professor Morton.
17. Poultry Husbandry. Professor Graham.

Enrollment for Correspondence Courses. — Students may enroll in the courses any time between October 1 and June 1 of the following year. It has been found advisable not to continue the courses through the summer because the farmers as well as the other students are so busy that they cannot spend the necessary amount of time upon the lessons during the summer months.

Expenses of the Correspondence Courses. — In order that none may enroll but those who are interested and desire to pursue earnest study, a small fee is

charged. This has been fixed at the rate of $1 for each course except Courses 8 and 17, where it is necessary to charge $1 for each of the parts. The fee is payable strictly in advance, at the time the enrollment card is sent, and the first lesson of the course is not sent until the fee is paid.

2. LECTURES AND DEMONSTRATIONS. — The members of the faculty of the college are glad to give lectures and demonstrations before granges, men's clubs, women's clubs, Y. M. C. A.'s, farmers' clubs, boards of trade and other organizations. A list of more than 40 lecturers and 200 subjects on various phases of agriculture, country life, economics, sociology, education, civic betterment and various scientific subjects has been prepared. Full courses of lectures or single lectures may be arranged.

Organizations arranging the lectures are asked to pay traveling expenses of the lecturer, provided no admission to the lecture is charged. If admission is charged, then the lecturer is entitled to a fee in addition to traveling expenses.

3. EXTENSION SCHOOLS. — Probably the most valuable work done away from the college is in the "Extension Schools." The college sends a corps of instructors to a town for a five-day school of instruction. At present, the following courses are offered: soil fertility, animal husbandry and dairying, fruit growing, poultry and home economics.

It is also possible to arrange special Extension Schools along one line of work, such as fruit growing or any other subject in which the college has facilities for giving the work.

Communities desiring an Extension School make a written request for the same, agreeing to defray all local expenses, such as the rent, heating and lighting of a suitable hall, and the board of the instructors during the school.

4. EDUCATIONAL EXHIBITS AT FAIRS AND OTHER SHOWS. — The college co-operates with the managers of fairs, industrial expositions, corn shows, poultry shows, fruit shows and other exhibitions by making educational exhibits.

For outside work a large tent has been provided. In this about thirty cabinets containing educational material are arranged in an attractive way. Accompanying the exhibit is a corps of lecturers and demonstrators who give practical instruction daily.

For inside work a space at least 40 by 60 feet is required for this exhibit.

Smaller exhibits along special lines are sent to corn, fruit and poultry shows, child welfare exhibits, milk shows and so forth.

The managers of fairs and exhibits are asked to help defray the expenses of putting on these exhibits.

5. EDUCATIONAL TRAINS. — The college, through the Extension Service, is glad to co-operate with railroad and trolley lines in the operation of educational trains and cars. The railroad usually furnishes the means of transportation, and looks after the operation of the train or cars. The college furnishes the exhibit and provides the lectures and demonstrations.

EXTENSION WORK CONDUCTED IN DIFFERENT PARTS OF THE STATE.

1. EXTENSION WORK IN FRUIT GROWING. — This work includes lectures and demonstrations on laying out and planting orchards, pruning, spraying, thinning, grading, packing and marketing fruits. Demonstration orchards, new and renovation plots, are being established all over the State, co-operatively between the college and the owners of land. Extension Schools of fruit growing and fruit grading and packing are arranged on request. Visits to

farms for advisory work are made so far as possible, and correspondence on orcharding subjects is invited.

2. Extension Work in Dairying and Animal Husbandry. — This work includes lectures and demonstrations on subjects pertaining to milk production, handling and marketing butter, and cheese making, instruction in barn planning, helps on swine and sheep raising. Assistance in organizing dairy improvement associations and breeders' associations is given; stock-judging contests for boys are arranged at the leading fairs; city milk inspectors may receive instruction for their work in feeding, scoring stables and so forth. Communities desiring to have campaigns conducted which seek to educate producers, dealers and consumers as to the production of clean, safe milk may make arrangements for these.

3. Extension Work in Poultry Husbandry. — Besides conferences at the college and visits to the plants of poultrymen, giving advice on general poultry management, diseases, mating, laying out and planning buildings, and so forth, this work includes co-operative work with State institutions, county schools of agriculture, agricultural departments in high schools, manual training departments in public and normal schools and exhibits of poultry appliances at fairs and shows.

4. Extension Work in Farm Management, Field Studies and Demonstrations. — This work is carried on co-operatively between the college and the office of farm management of the United States Department of Agriculture at Washington, and consists in studying farm conditions and farm management problems; in instruction in keeping farm accounts, growing field crops; in the use of fertilizer and lime; in giving advice as to farm equipment, buildings, and so forth.

5. Extension Work in Civic Betterment. — This work is carried on in connection with the department of landscape gardening at the college. Assistance is given in all kinds of rural and village improvement enterprises, such as the planting and care of shade and street trees, the planning of playgrounds, school grounds, cemeteries, picnic grounds, the beautifying of water fronts, the rearrangement and development of town commons, reservations of historic interest, and so forth. The co-operation of local granges, men's and women's clubs, village improvement societies and similar organizations is desired.

6. Extension Work in Agricultural Education. — The extension work of this department is devoted to the promotion of agriculture and practical arts relating to country life in the public schools of the State. This is done by means of conferences with school officials and school patrons, the promotion of agricultural clubs among the school children and the giving of lectures before granges, farmers' clubs, and other organizations interested in this line of endeavor. The work of the agricultural clubs is under the local management of the superintendent of schools or of some one recommended by him. Each town is expected to hold an exhibit of products. Exhibits covering rather extensive districts are incorporated with the various agricultural fairs in the State. In this way the promotion of elementary instruction in agriculture is carried on by the combined efforts of the public schools, of the patrons of the schools through their agricultural fairs, and of the Agricultural College.

7. Extension Work in Home Economics. — The home economics department stands ready to assist in solving problems relative to the household in the same manner as other departments of the Extension Service do the problems of the farm. The work includes lectures and demonstrations,

assistance in forming girls' clubs and home economics clubs for women, and co-operation with any existing organization in the matter of interesting young people in the proper care of the home.

8. Extension Work in Community Service. — Several communities in the State have appealed to the college for help and advice as to how all the organizations in the community can be brought to a higher state of efficiency, and as to what steps the communities themselves might take toward community development and advancement. The college is now prepared to make scientific studies of communities which lead up, by means of surveys, to the definite organization of committees to study the agricultural, educational, religious, transportation, recreation and civic needs of the communities. Usually several State organizations and some national organizations are brought in to help in working out these plans. Conferences on community affairs are organized and held when requested. The college acts simply in an advisory capacity, the communities themselves doing the actual organizing work.

9. Demonstration Auto Truck. — In order to reach all communities of the State more effectively, a demonstration auto truck has been procured. This truck is equipped with spraying apparatus, pruning tools, Babcock milk tester and other dairy apparatus, dairy record blanks, farm account blanks, a radioptican with sets of pictures for illustrative use, books, bulletins, pamphlets and other equipment. This outfit, in charge of a competent instructor or demonstrator, visits towns and farms of the State upon request, and gives lectures and demonstrations along the lines most interesting to the community.

10. Library Extension Work. — This work consists principally of sending out to the public libraries of the State collections of books and bulletins on agriculture and related subjects. General collections of 10 to 30 books and bulletins are loaned to libraries, also special collections of smaller size on specified subjects, such as fruit growing, dairying, poultry, bees, home economics, etc. These books may be kept for a period of from four to eight weeks, according to the demand for them. The only expense is cost of transportation of the books both ways. The college library also supplies information about books on agriculture and related subjects upon request.

11. Agricultural Surveys. — In order to acquire definite information about existing conditions in rural communities, which may be later used as a basis for further extension work, agricultural surveys are being made as rapidly as possible. The different organizations and officials in the community, such as the town officers, superintendent of schools and teachers, clergymen, librarians and others usually co-operate in making the survey. The survey covers every side of the community life including soil survey, farm management practices, and the educational, social, religious and recreational life. Carefully prepared blanks have been provided on which the inventory is made.

12. Agricultural Co-operation and Marketing. — This department, which is just being started at the college, has for its object the establishment of agriculture on a better business basis. Assistance can be given in the organization of co-operative buying and selling associations, rural credit, the finding of a better market for agricultural produce and other lines of agricultural co-operation.

13. Massachusetts Agricultural College Agricultural Improvement Association. — This is an organization of ex-students of the college

who are farming in the State and who have banded themselves together for the purpose, according to the constitution of the association, of "promoting the agricultural development of the State by carrying on experiments and demonstrations for the betterment of rural pursuits, by using and encouraging the use of better seeds and animals, by the organization of co-operative societies, by the dissemination of literature bearing on recent agricultural investigations," and so forth.

High-grade strains of corn and potatoes are being produced by the members for the Massachusetts seed trade. The growing of alfalfa is now being taken up. Work with animals will soon begin.

14. Demonstration Farms and Plots. — Believing that one of the most effective ways of teaching modern farm practice is by the establishment of demonstrations (not experiments) in all sections of the State, thus showing a man on his own land and under his own conditions the result of proper farm practices, the college is placing demonstration plots throughout the State, showing proper fertilization of grass land and other crops, results of rotations, proper care of orchards and dairy management. For more than three years the Faunce demonstration farm has been under the advisory direction of the college. This farm has proved to the Cape Cod region that small fruits, poultry and vegetables can be successfully grown there. The management of demonstration farms is usually carried on by a committee or board of trustees representing the farm and a committee appointed from the college acting jointly.

15. County or District Agricultural Advisers. — As rapidly as State and government funds are available, men trained in agriculture are being assigned to counties and districts of the State to act as agricultural advisers. Residents of the county or district may, without cost, call upon the adviser for help upon any agricultural subject. The work is being developed through the co-operation of the United States Department of Agriculture, the college and the community engaging the adviser.

16. Student Extension Work. — The social service secretary of the college, in co-operation with the Extension Service, is developing this work.

Students of the college, so far as their time will permit, will give lectures and demonstrations on agricultural subjects, teach English and civics to foreigners, coach and supervise athletic contests with boys and girls, help organize and conduct debating societies and Bible classes, give talks on true sportsmanship and clean living, give musical entertainments and act as judges and helpers at fairs and other exhibits.

17. Advisory Work with Institutions and Individuals. — Special effort is made to comply with as many of the requests of State institutions and individuals who ask for advice on farm problems as possible. The force of instructors available for this work is not at present sufficient, and it is hoped a competent man will be engaged in the near future for this work.

18. Publications of the Extension Service. — Beside the regular circulars and bulletins which announce the various short courses and lines of work mentioned, a monthly pamphlet, "Facts for Farmers," giving timely information on agricultural subjects, is issued. Reports of the work of the Extension Service, dairy record blanks, farm account blanks, boys' and girls' club circulars, lists of books, and so forth, can be had upon request.

19. Co-operation with Other Organizations. — The aim of the Extension Service is to co-operate with existing organizations so far as possible. It

is, therefore, glad to help local organizations and welcomes suggestions from such organizations as town officers, local granges, farmers' clubs, women's clubs, Y. M. C. A.'s, Y. W. C. A.'s, boards of trade, village improvement societies, teachers, clergymen, librarians and others interested in agriculture and country life.

20. Information by Correspondence. — Besides these things already mentioned thousands of helpful circulars and bulletins are printed and distributed, hundreds are helped through personal visits to farms, and still larger numbers through letters of inquiry which always receive the most careful attention from every department of the institution.

Pamphlets and bulletins are sent free to all who ask for them, and correspondence from any who desire such help as has been mentioned is gladly received. Address all communications to the Director of the Extension Service, Massachusetts Agricultural College, Amherst, Mass.

General Information.

General Information.

A. FINANCIAL AND ADMINISTRATIVE.

STUDENT EXPENSES.

Tuition.[1] — Tuition is free to residents of Massachusetts. Students who are not residents of Massachusetts are charged a tuition fee of $40 a year. The tuition charged persons not citizens of the United States is $120 a year. Students entering from Massachusetts are required to file with the president a statement signed by either town or city clerk stating that the applicant's father is a legal resident of Massachusetts; a similar statement is required of those entering from other States.

Dormitories and Board. — The college has dormitory accommodations for about 62 students. The rooms in the dormitories are occupied by the upper classmen, hence new students find it necessary to room in private houses. The rooms in the college dormitories are unfurnished; for the most part they are arranged in suites of three, — one study room and two bed rooms. These rooms are heated by steam and lighted by electricity; they are cared for by students occupying them. The dormitory rent for each person varies from $39 to $66 a year. The rent for furnished rooms in private houses ranges from $1 to $3 a week for each occupant. Correspondence in regard to rooms should be addressed to the dean of the college.

Board may be obtained at the college dining hall. At present the price of board there is about $4 a week. Board is furnished at cost, the price being determined by adding 5 per cent. to the audited rate for the previous three months, and at the end of the period final settlement is made on the basis of actual cost.

EXPENSES.

The necessary college expenses are estimated as follows: —

Tuition: citizens of Massachusetts free; other citizens of the United States, $40 a year; foreigners, $120 a year.

	Low.	High.
Room in college dormitories or in private houses,	$39 00	$110 00
Board in college dining hall, $4 a week,	144 00	144 00
Laundry, 50 cents to 85 cents a week,	18 00	30 00
Military uniform, first year,	17 85	17 85
Laboratory fees,	2 00	20 00
Books, stationery and miscellaneous items,	19 15	28 15
	$240 00	$350 00

Other Expenses. — Prospective students should understand that the above estimates cover expenses which may be called strictly college expenses, and that there are other financial obligations voluntarily placed upon students

[1] This statement applies to those registering as regular or unclassified students.

which they should expect to meet. Chief among these are class assessments and taxes levied for maintenance of various organizations, such as the Social Union, Athletic Association, weekly publications, etc. Such expenses vary from $15 to $30 a year. Additional financial responsibility is also assumed by students joining a fraternity or entering into other social activities of the college. Students rooming in college dormitories are obliged to equip their own rooms with furniture. The college assumes no responsibility in regard to the safe keeping of student property either during the college term or vacations, except under such special arrangement as may be made with the treasurer. Besides the amount necessary for clothes and traveling, the economical student will probably spend between $250 and $350 per year.

Initial Charges.

At the opening of the college year, before students are registered in their classes, the following charges are payable at the treasurer's office: —

	Freshmen.	Sophomores.	Juniors and Seniors.
Board (if at college dining hall) four weeks in advance,	$16 00	$16 00	$16 00
Subscription to "Signal" (college paper),[1]	1 50	1 50	1 50
Assessment for support of Social Union,	1 00	1 00	1 00
Laboratory fees: —			
Chemistry,	5 00	-	-
Zoölogy,	-	2 00	-
For elective subjects,	-	-	1 00–10 00
Military uniform,	17 85	-	-
Room rent (if in college dormitory),	-	-	19 50–33 00
Student tax for support of athletics,[1]	8 00	8 00	8 00
	$49 35	$28 50	$47 00–$69 50

[1] While this is not essentially a college charge, the treasurer of the college acts as collector for the student activity, and all students are expected to make the payment as indicated. The subscription price of the "Signal" is fixed by the managers; the amount of athletic tax by vote of the student body.

Laboratory Fees.

The principles observed in establishing laboratory fees are the requirement that students pay for those materials actually used which cannot be supplied by the individual, and that the laboratory fees include a charge sufficient to guard against wanton waste and breakage.

	Per Semester.
Agronomy: —	
Course 3,	$1 50
Course 4,	0 50
Courses 5 and 6,	1 00
Animal husbandry: —	
Courses 2 and 4,	$1 00
Course 7,	2 00

	Per Semester.
Botany: —	
Courses 2, 3, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16,	$3 00
Course 4,	2 00
Course 5,	1 00
Chemistry: —	
Courses 1, 2, 7, 8, 13, 15,	3 00
Courses 3, 4, 5, 6,	4 00
Courses 9, 10, 11, 12, 14, 16,	5 00
Dairying: —	
Courses 1, 2, 3,	1 00
Entomology: —	
Courses 3, 4,	3 00
Landscape gardening: —	
Landscape gardening 1, 2,	2 50
Landscape gardening 3, 4, 7, 8,	3 00
Landscape gardening 6,	1 00
Drawing 1, 2,	2 50
Mathematics: —	
Courses 6, 10,	1 00
Microbiology: —	
All courses, each,	5 00
Pomology: —	
Courses 3, 4,	2 50
Poultry husbandry: —	
Course 3,	1 50
Course 4,	2 00
Zoölogy: —	
Course 1,	2 00
Courses 3, 4,	4 00
Dairying 1, 2, 3, 4,	1 00

STUDENT AID.

Self Help. — Many students are obliged to find work of some sort to earn their way through college. A few men have met their entire expenses in this manner, many more have paid a large part of their expenses, and many have earned a small proportion of the cost of their college education; but the college recommends that no new student enter without having at least $150 with which to pay his way until he can establish himself in some regular work. The college does not encourage students to enter without money in the expectation of earning their way entirely. The ordinary student will find it better either to work and accumulate money before coming to college, or to take more than four years in completing his college course, or, instead, to borrow money sufficient to carry him through. No student should undertake work that interferes with his studies, and students should understand that, owing to the large number of applications for employment, no one man can receive a large amount of work at the college. A number of students find opportunities for earning money without depending upon the college to furnish them with work.

So far as possible needy students will be employed in some department of the college. The divisions of agriculture and horticulture usually afford the most work, although there are several permanent janitorships available for students, and sixty or more students are employed at the dining hall.

Applications for student labor should be made directly to the President. Applicants are required to present statements from parent or guardian and from a selectman or alderman of the town or city in which they reside, showing that the applicant needs assistance. Students whose deportment or class work is not satisfactory are not likely to be continued in student labor. The most desirable and responsible positions are naturally assigned to those needy students who have been in the institution longest and who have demonstrated their need and ability. Students, therefore, may find it rather difficult to obtain all the work they desire during their freshman year; as a matter of fact, however, any student who is capable of doing a variety of things, and who is a competent workman, usually finds little difficulty in obtaining all the work that he can do from the outset.

Special Notice to Needy Students. — In the last year or two the demand for paid labor on the part of new students has far exceeded the amount of employment that the college can offer. The college cannot promise work to any student, particularly to freshmen; it accordingly urges prospective students who are dependent entirely upon their own efforts not to undertake the course before they have earned enough money to carry them through, or nearly through, the first year.

STUDENT ACCOUNTS.

The following rules are enforced concerning student accounts: —

No student will be allowed to graduate until all bills due the institution from him are paid.

College charges, such as room rent, laboratory fees and tuition, must be paid in advance, at the beginning of each semester. This rule is strictly adhered to, and no student will be allowed to register in his class until such payments are made.

Every student boarding at Draper Hall is required to pay at the beginning of each semester at least one month's board in advance; and no student will be allowed to continue to board at Draper Hall if at any time during the semester he is more than one week in arrears in his payment for board.

All money due for student labor shall at the discretion of the treasurer of the college be applied on account toward any bills that a student may owe to the institution.

STUDENT RELATIONS.

The customary high standard of college men in honor, manliness, self-respect and consideration for the rights of others constitutes the standards of student deportment.

Any student known to be guilty of dishonest conduct or practice must be reported by the instructor to the President for discipline.

The privileges of the college may be withdrawn from any student at any time, if such action is deemed advisable.

It should be understood that the college, acting through its President or any administrative officer designated by him, distinctly reserves the right not only to suspend or dismiss students, but also to name conditions under which students may remain in the institution. For example, if a student is not doing creditable work he may not only be disciplined but he may also be required to meet certain prescribed conditions in respect to his studies, even though under the foregoing rules his status as a student be not affected. The same provision applies equally to the matter of absences ("cuts"). According to the rules a student is allowed a certain percentage of absences from class

and other exercises. This permission, which implies a privilege and not a right, may be withdrawn at any time for any cause.

Similarly, also, it applies to participation in student activities. Though this will ordinarily be governed by the rules as already laid down, yet, if in the judgment of the college authorities a student is neglecting his work on account of these activities the privilege of participating in them may be withdrawn for such time as is considered necessary. Moreover, it may be withdrawn as a punishment for misconduct. Prospective students or their parents may, upon application, obtain a copy of the faculty rules governing student relations to the college.

B. COLLEGE ACTIVITIES.

GENERAL EXERCISES.

Chapel exercises are as a rule held four mornings each week. On Wednesday, instead of chapel an afternoon assembly is held, to which some prominent layman or professional man is invited to speak. The object of these assemblies is to bring to the students discussions of topics of present-day interest. A special chapel service on Sunday is usually held during the winter months. Students are required to attend these general exercises, although the president is authorized to excuse from chapel any student who may object to attendance thereon because of his religious scruples, provided his request for excuse therefrom is endorsed by his parent or guardian.

STUDENT ACTIVITIES.

A large number of student organizations furnish opportunity to students for work and leadership.

The Massachusetts Agricultural College Social Union was established about six years ago. All students become members of the Union by paying a small fee. The Union is designed to become the center of student interests. In North College it has a trophy room and a large lounging room for music, reading and study. In the basement of this building there is also a game room for pool and billiards. In the fall and winter months the Union gives a series of entertainments, free to students and faculty.

The College Senate is composed of representatives of the junior and senior classes. This body serves as a general director of under-graduate conduct, and represents before the faculty the interests of the student body.

The M. A. C. Christian Association is active both socially and religiously. Under its direction voluntary Bible classes are conducted during the winter months. A Catholic Club has also been organized.

The musical organizations include an orchestra, a mandolin club and a glee club. These furnish music for college meetings, and occasionally give concerts at the college and at other places. A military band is maintained as part of the cadet corps.

A Dramatic Club has been organized, and each year presents a play.

The Public Speaking Council represents the students' interest in debate and oratory.

The Athletic Association represents in the college the interests of football, baseball, track, hockey and tennis.

A Rifle Club has been organized for a few years. Teams representing this club have repeatedly won the intercollegiate championship of the country, both in indoor and outdoor contests.

The college publications are the "Signal," published weekly by the student body, and the "Index," published annually by the members of the junior class.

The Stockbridge Club is an organization of students especially interested in practical agriculture and horticulture. Regular meetings are addressed by outside speakers, and members present papers and engage in discussions.

Scientific clubs also exist in the departments of French, entomology, landscape gardening, and zoölogy.

C. ACADEMIC AND DEPARTMENTAL.

DEGREES.

Those who complete a four-year course receive the degree of bachelor of science. The fee for graduation from the college is $5.

Graduate students who complete the assigned courses will receive the degree of master of science upon the payment of a fee of $10. Credit may sometimes be allowed towards this degree for teaching or other advanced work done in some department of the college.

Graduate students who complete the required three-year course of study, and present a satisfactory thesis, will be granted the degree of doctor of philosophy.

Those to whom degrees are awarded must present themselves in person at commencement to receive them. No honorary degrees are conferred.

The honorary fraternity of Phi Kappa Phi has a chapter at the agricultural college. Students are elected to membership to this fraternity on the basis of scholarship. Elections are made from the highest fifth of the senior class who have attained an average grade of at least 85 per cent. during their college course.

PRIZES.

Prizes are given annually in several departments for excellence in study or for other special achievement. Prizes offered in 1913 were: —

Agriculture. — The Grinnell prizes (first, second and third), given by the Hon. William Claflin of Boston in honor of George B. Grinnell, Esq., of New York, to those members of the senior class who pass the best, second best and third best examinations, oral and written, in theoretical and practical agriculture. They are $25, $15 and $10.

Animal Husbandry. — The F. Lothrup Ames' Prize, given by F. Lothrup Ames, Langwater Farms, North Easton, Mass., consisting of $150 a year, offered for a period of five years, beginning 1912, to be given to the three students standing highest in the work of advanced live-stock judging, and to be used in defraying their expenses incurred by participation in the students' judging contest at the National Dairy Show, Chicago.

Botany. — The Hills prizes (amounting to $35), given by Henry F. Hills of Amherst, will be awarded to members of the senior, junior and sophomore classes as follows: for the best herbarium, $20; for the best collection of Massachusetts trees and shrubs, $15. No collection deemed unworthy of a prize will be considered.

General Improvement. — The Western Alumni Association prize ($25) is given to that member of the sophomore class who, during the first two years in college, has shown the greatest improvement in scholarship, character and example.

Public Speaking. — The Burnham prizes are awarded as follows: to the students delivering the best and second best declarations in the Burnham contest, $15 and $10, respectively. The preliminary contests in declamation are open, under certain restrictions, to freshmen and sophomores.

The Flint prizes are awarded as follows: to the students delivering the best and second best orations in the Flint contest, a gold medal and $20 and $15, respectively. The preliminary contests in oratory are open, under certain restrictions, to all regular students.

The prizes in debate are awarded as follows: to each of the three students ranking highest in the annual debating contest, a gold medal and $15. The preliminary contests in debate are open, under certain restrictions, to all regular students.

EQUIPMENT.

Agronomy. — The work in agronomy is carried on by means of lectures, laboratory work and field work. The laboratories are in the north wing of South College. The seed laboratory is equipped with samples of the different grains and seeds of economic importance in field culture, and with apparatus for the study and testing of these seeds, including microscopes and the apparatus necessary for viability and purity tests. The soil laboratory is equipped with apparatus for studying the physical properties of soils, and with tools used in the reclamation of land by drainage and by irrigation. A large part of the work is done in the field, the college farm being used as a laboratory.

Animal Husbandry. — An accurate and definite knowledge of the market types and grades, and of the various breeds of live stock, is fundamental to the work of this department. The department is equipped with an excellent laboratory, Grinnell Arena, which has a seating capacity of 180, and which is fully adapted to the requirements. There are upwards of 125 head of dairy cattle of various ages available for class-room work; among these are included superior representatives of the Jersey, Guernsey, Ayrshire and Holstein breeds. There are flocks of pure-bred Shropshire and Southdown sheep of the best breeding and individuality. Considerable numbers of pure-bred Berkshire and Yorkshire pigs are maintained. The college possesses pure-bred Percherons and French coach horses, besides many work teams of different types, which are available for class-room purposes. A set of plaster of Paris models of individuals of foreign and domestic breeds of horses, cattle, sheep and swine, and a collection of the different foodstuffs available for the use of the New England farmer, are included in the equipment for this work. This equipment is being added to from time to time as funds are available.

Botany. — The department of botany occupies Clark Hall, a brick building 55 by 95 feet, two stories high, with basement and attic. It has two lecture rooms, one seating 154 and the other seating 72 people; one seminar and herbarium room; a large laboratory for sophomore and junior work, and one for senior work; and three rooms specially fitted for graduate students. The experiment station laboratories devoted to botanical research are also in this building. A small museum contains material especially useful in the teaching and illustration of plant phenomena; and on the third floor is a collection of Massachusetts timber trees, specimens showing peculiar formations of plant growth, and various specimens illustrative of scientific methods of treating trees.

The laboratories and lecture rooms are of modern construction, finely lighted and supplied with all necessary conveniences. The basement con-

tains a bacteriological laboratory, a seed and soil room; and a convenient workshop provided with benches for wood and metal work, an electric motor, a power lathe, and other tools and appliances. In the senior laboratory is a room designed especially for physiolcgical work; this laboratory is well supplied also with apparatus for the study of simple phenomena in plant physiology, such as respiration, metabolism, transpiration, heliotropism, etc. The herbarium contains 15,000 species of flowering plants and ferns, 1,200 sheets of mosses, 1,200 sheets of lichens and liverworts, and about 12,000 sheets of fungi. The laboratory is equipped with 90 modern compound microscopes and a number of dissecting microscopes, microtomes and a large series of charts. A conservatory 28 by 70 feet is connected with the laboratory. This is designed for experiment work and for housing material often needed in the laboratory.

Chemistry. — The chemical department of the college occupies the entire building previously known as the "old chapel." The basement is used for the storage of apparatus and chemicals. The first floor contains large laboratories devoted to qualitative and quantitative analysis and organic and physiological chemistry. The second floor is occupied by the general lecture room, by offices for the several members of the staff, by laboratories for physical chemistry and for beginners in quantitative analysis. The third floor has been fitted for work in general chemistry, and has desk room and hoods sufficient to accommodate 66 students at one time. Each place is supplied with reagents and apparatus for independent work. This floor is also occupied by a lecture room that will seat 100 students.

The entire laboratory is well equipped with the necessary apparatus and chemicals for all students who desire to perfect themselves as expert chemists, or who wish to study chemistry as a supplement to some other line of practical or scientific work. The equipment includes a valuable and growing collection of specimens and samples of minerals, soils, raw and manufactured fertilizers, foods, milk products, fibers, various other vegetable and animal products and artificial preparations of mineral and organic compounds; and also a series of preparations for illustrating the various stages of different manufactures from raw material to finished product.

Dairying. — The dairy department is now using the new dairy building, Flint Laboratory. The dairy work is done in several new laboratory rooms equipped with the best apparatus for market milk and dairy butter work. Flint Laboratory is considered one of the best equipped dairy instruction buildings in the country.

Dining Hall. — Draper Hall, a brick colonial building, equipped with the modern conveniences of a dining hall, was opened in 1903. The dining service is under the supervision of the college. The building contains a limited number of rooms for young women students.

Drawing. — The class in drawing occupies a room on the second floor of Wilder Hall. It is equipped with tables and adjustable drawing stands. The necessary materials and implements are provided. The equipment includes drawing models, and plaster casts of leaves, flowers, fruits, human and architectural details, and garden ornaments, two universal drafting machines, an eidograph, centrolineads, a set of ship splines and French curves, complete water-color outfits, automatic crosshatchers and protractors.

Entomology. — General Entomological Laboratories. — The equipment for work in entomology is perhaps unexcelled in this country. In

the new fireproof entomological and zoölogical building, first used in the fall of 1910, are fine lecture rooms, laboratories and museums for use in the different courses. The senior laboratory will accommodate 70 students at one time; a desk, equipped with compound microscope and accessories, together with glassware, reagents, etc., and supplied with electric light and gas is provided for each student. Dissecting microscopes, microtomes and other apparatus are available for use. The graduate laboratory is similarly equipped, and it will accommodate 20 students. The large and rapidly growing collections of insects are in a room adjoining both laboratories. In the library of the building is an excellent collection of the more important books and journals treating of entomology, and many more are accessible in the college library and in the private libraries of the professors, in all making available more than 25,000 volumes, many of which cannot be found elsewhere in the United States. A card catalogue giving references to the published articles on different insects contains more than 60,000 cards, and is the largest index of its kind in the United States, and probably in the world. In the basement is a pump room where may be studied the construction of the different types of spray pump and methods of repairing them; hose, couplings, nozzles and the other parts of spraying outfits are provided, not only for examination but for use. In another room, provided with chemical desks and apparatus, methods for the determination of the impurities and adulterations of insecticides are taught. As the insectary of the Massachusetts Agricultural Experiment Station is in the same building the facilities it offers are also available. A greenhouse, where plants infested with injurious insects are under observation and experimental treatment, is also open to students. Photographic rooms with cameras and other photographic apparatus are provided, and the large greenhouses, gardens, orchards and grounds of the college offer further opportunities for the study of injurious insects under natural conditions.

Entomology. — Beekeeping. — For this work the main office, museum and lecture rooms are in the entomological building. There is also an apiary covering approximately two acres which will consist of about fifty colonies of bees in various types of hives and maintained for the several practical and experimental purposes. The apiary also includes a collection of nectar-yielding plants representative of the native flora as well as of the more important nectar sources from other localities. Especial opportunity is therefore given for a study of this fundamental problem of forage. Upon the apiary site is an eight-room building (the first in the world erected exclusively for teaching beekeeping) modeled to meet both the requirements of teaching and of a practical apiary. This building contains a boiler room, capacious wintering cellar, wax extraction room, general carpenter and work shop, laboratory, office, honey extraction room and stock room. The beekeeping equipment also includes an unexcelled collection of apicultural implements, natural history specimens and other curiosities. Practically every device used in American apiculture is available, it being the aim of the department to procure new inventions and implements as fast as they appear for the purpose of study and comparison. Available to the students is a private library of apicultural literature consisting of upwards of 700 volumes and papers, possibly the most complete collection in the country. This entire equipment is acknowledged unique in model and in completeness for the United States and for the world.

Farm Administration. — The college farm of 250 acres is under the general supervision of the Department of Farm Administration, and furnishes demonstration material. It includes improved land, pasture land and a farm wood lot. The improved land illustrates the value of good culture and the best known methods for the maintenance of fertility. The farm is equipped with suitable buildings and good machinery for the work carried on, of which the production of certified milk is an important branch. Several good farms in the vicinity, illustrating types of both special and general agriculture, may be inspected and studied.

Agricultural Education. — The courses in this department are planned primarily for those who are preparing to teach. The work is carried on by means of lectures, library and demonstrations. The department has an office, lecture room and a laboratory in the Veterinary Science building. The laboratory is equipped with a balance, dishes, jars, reagent bottles, test tubes, petri dishes, lenses, a Babcock test, a Wisconsin sediment test, Bunsen burner, hot and cold water, electricity, gas and other appliances for giving demonstration and practice lessons in Secondary Agriculture. There is also equipment for conducting children's gardens on the campus. Instruction in school gardens constitutes a part of the practice work of those training for the occupation of teaching. Some practice work in teaching is done in the grammar grades of the Amherst schools, and in the agricultural departments of Hopkins' Academy, and Smith's Agricultural School at Northampton. This department is also intimately related to the matter of recommending candidates for teachers' certificates. At least four courses in the department are required of students preparing for such certificate. The office is supplied with school and college reports, also a large number of pamphlets and bulletins relating to the subject of agriculture in the schools, courses of study, etc. See note relative to teachers' certificates, under major in Agricultural Education.

Floriculture. — The department of floriculture aims to give the student a thorough knowledge of all phases in greenhouse design and construction and greenhouse heating, and in the culture of florists' crops. It is intended to train men for commercial floriculture and for the management of conservatories on private estates and parks and in cemeteries. The course is outlined to combine theoretical, technical and practical work in the most comprehensive manner possible. Probably no agricultural college has a department of floriculture better equipped than this. There has been erected a durable, practical, commercial range, composed of palm, fern, orchid, violet, carnation, rose and students' houses. French Hall, with its large laboratories, class rooms and offices, furnishes excellent facilities for the purposes of instruction. Besides the new glass houses, there are older houses suitable for growing bedding plants and chrysanthemums, and frames for the growing of annual and herbaceous perennial plants, violets and pansies. Many excellent specimens of trees and shrubs are growing on the college grounds, furnishing valuable material for the study of plant materials.

Forestry. — The department of forestry has an unusually complete equipment of the various instruments used in forest mensuration, forest mapping and engineering, timber estimating, log scaling, board measuring, etc.; a large assortment of boards illustrative of the various commercial woods found in the lumber markets. The State Forest Nursery, comprising 6 acres of land and containing, approximately, 5,000,000 trees, transplants

and seedlings is located on the college farm. Extensive forests containing every variety of tree common to New England are within walking distances of the college. The college campus affords an arboretum containing an exceptionally large number of trees not native to New England. The library contains complete sets of government bulletins, circulars, State reports and all the best books on forestry subjects.

Geology. — A large, well-lighted laboratory for geology, 27 by 50 feet, is in the basement of the new building for entomology, zoölogy and geology. This is equipped with cabinets, models, charts and a teaching collection of rocks. It has a seating capacity of 50 persons. Adjoining this is a smaller laboratory, 21 by 27 feet, for mineralogy, supplied with gas and cabinets for models, crystals and minerals. There is also a small laboratory for grinding thin sections, and a private laboratory, 6 by 19 feet, for analysis work. The geological museum is 27 by 48 feet. It has six large cases for exhibition purposes.

The equipment for geology is being enlarged. At present, in addition to the general items mentioned above, it consists of a petrographic microscope, an illustrative series of thin sections, a small collection of invertebrate fossils, some casts of vertebrate fossils, a collection of the building stones of Massachusetts, and a duplicate set of the Edward Hitchcock survey collection of the rocks and minerals of Massachusetts.

Heating, Lighting and Power. — The college supplies its own light, heat and power, including electricity for the night lighting of the campus and its approaches. The machinery of the barn, the dairy and other buildings is operated by electricity generated at the power-house. The college has also a machine shop and well-equipped carpenter shop.

Landscape Gardening. — The work in landscape gardening is developed in a strong technical four-year course; the first two years are occupied with required studies, including botany, horticulture, surveying and mathematics, and the last two years are devoted to more specialized studies in landscape gardening, arboriculture, floriculture, entomology, botany and mathematics. The environment is unusually favorable. The strictly technical work in landscape gardening is taught in light and comfortable drafting rooms, fully furnished with instruments and accessories for thorough work. There is a well-selected library, and the equipment of surveying and drafting instruments is unusually complete and practical.

Library. — The library — stack room, reading room and office — occupies the entire lower floor of the Chapel-library building. It contains nearly 42,000 volumes and a large number of pamphlets, hitherto inaccessible, but which are being put into good working order as fast as possible. Works of a scientific character predominate, but economics, literature and history are well represented and are receiving due attention. The reading room provides a variety of periodical literature, both technical and popular, encyclopedias and general reference books.

The library is now being reclassified and recatalogued, to make the splendid collection of material here gathered together readily accessible and of the greatest working value. Every effort is being made toward developing the library into a vital intellectual center of college life, of equal value to every student, teacher and teaching department. In consequence, only the most cordial relations are cherished, and the fewest and most imperative rules concerning the circulation of books and deportment are enforced.

Lectures are given to regular and short-course students to enable them to make the best use of the library. Emphasis is laid upon the proper use of the card catalogue, periodical indexes, bibliographies and guides; also, in general, assigned and class-room work, and essay and debate work.

The library hours are from 7.30 A.M. to 9.30 P.M. every week day, and from 9 A.M. to 2 P.M. on Sundays, in term time. Shorter hours prevail during vacations.

Market Gardening. — The purpose of the courses in market gardening is to acquaint the student with the theories and practice of market gardening so that he will be able to carry on the business intelligently. The equipment available for practical work consists of 10 acres of good gardening land; a large collection of horse and hand garden tools; hot-beds and cold-frames; and lettuce, cucumber and tomato houses. The students therefore have opportunity both to study and to practice the important branches of the business. Classes are taught in French Hall, a new building fitted with class rooms and laboratory particularly equipped for market gardening. A good library of works on vegetable gardening is available.

Mathematics and Civil Engineering. — *Surveying.* — The department has a considerable number of the usual surveying instruments, with the use of which the students are required to become familiar by doing field work. Among the larger instruments are 2 plain compasses, a railroad compass with telescope, a surveyor's transit, 3 engineer's transits with vertical arc and level, a Brandis solar transit, a solar compass, an omnimeter with verniers reading to 10 seconds, adapted to geodetic work, a queen plane table, 3 wye levels, 2 dumpy levels, a builder's level, a sextant, a hand level, and a large assortment of leveling rods, flag poles, chains, tapes, etc. For drafting, a vernier protractor, a pantograph, a parallel rule, etc., are available. The department also has a Fairbanks cement testing outfit.

Military Science. — This department makes use of the campus for battalion drill, and has a special building in which there is a drill room 60 by 135 feet, an armory, an office for the commandant, a field-gun and gallery practice room and a large bathroom. The national government supplies Krag-Jorgensen rifles, with complete equipments and ammunition. The State supplies instruments for the college band. Students are held responsible for all articles of public property in their possession. The college owns an excellent target range for rifle practice, lying a short distance out of the village.

Physical Education. — The gymnasium and armory has a floor space of 5,000 square feet, and is 30 feet high, well lighted and ventilated. The main floor is used for basket ball, indoor baseball and hand ball. The gallery has been fitted up as a special exercise and gymnastic room, and is equipped with modern developing apparatus, including parallel bars, horses, bucks, chest weights, dumb bells, Indian clubs and striking bags. An outdoor board track enables students to secure track practice through the winter, and two ice hockey rinks give ample opportunity for hockey practice. Credit is given to all students taking part in outdoor activities. "Treks" are held twice a week, and whenever possible snowshoe and skiing hikes are also held. Steel lockers and bathrooms have been installed in North and South colleges, and the gymnasium has been fitted with a shower-room. The gymnasium classes are held the last two hours in the morning and the last two hours in the afternoon, but students may use the gymnasium at other times for exercise purposes

by arrangement with the Department. The regulation costume for class exercise consists of a white track suit and white rubber-sole shoes.

Physics. — Among the apparatus in use for instruction in general physics are a set of United States standard weights and measures, precision balances, a spherometer, vernier calipers, a projection lantern, etc.; in mechanics, a seconds clock systems of pulleys and levers, and apparatus to illustrate the laws of falling bodies and motion on an inclined plane, and the phenomena connected with the mechanics of liquids and gases. The department is equipped with the usual apparatus for lecture illustration in heat, light and sound; in electricity, the equipment consists of apparatus for both lecture illustration and laboratory work, including a full set of Weston ammeters and volt meters, a Carhart-Clark standard cell, a Mascart quadrant electrometer, a Siemens electro-dynamometer, and reflecting galvanometers and Wheatstone bridges for ordinary determinations of currents and resistances.

Pomology. — The department of pomology has 20 acres of orchard, including apple, pear, peach, plum, cherry and quince trees. Of particular interest is the large collection of these fruits on the various dwarf stocks, showing many types of training. The recent revival of interest in dwarf fruits makes these dwarf orchards of especial value to students. There are also two commercial vineyards, and a smaller one in which are shown the principal types of trellis and the leading methods of training grapes. Several acres are used in growing the various kinds of small fruits, such as strawberries, raspberries, blackberries, currants and gooseberries. There are also nurseries, where all of these various types of fruits are grown, in which students may see them in all stages of development.

The department has a good equipment of orchard and nursery tools of all the principal types, the use of which enables students to learn the value of each type. For other orchard operations, such as spraying and pruning, the most approved makes of pumps, nozzles, pruning saws, knives, etc., are provided. For laboratory work in systematic pomology there is a collection of more than 100 wax models of apples, plums, pears and peaches, in natural colors, which are particularly valuable in identifying varieties of these fruits unknown to the student. The laboratory is also furnished with a large number of reference books on pomology; and fruit in a fresh condition is available in great variety, not only from the college orchards but from other parts of Massachusetts and from many other States. In 1912–13, for instance, apples for class use were received from Idaho, Missouri, Utah, Washington, Maine, Connecticut, Pennsylvania, Montana, Minnesota, Nebraska, Kentucky, Iowa, Wisconsin, Michigan, New York, Kansas, Colorado, Oregon, New Jersey and Vermont, besides collections of grapes from California and citrus fruit from Florida and Texas. From the college fruit plantations the following fruits were available: grapes, twenty-four varieties, representing three native American species and several hybrids; six varieties of peaches, ten varieties of pears, eight varieties of plums, forty-six varieties of apples.

Poultry Husbandry. — The poultry plant consists of about 9 acres of land sloping gently to the west. The soil is a fine, rich, sandy loam, well drained. At present the buildings consist of an incubator cellar, 22 by 34 feet, with a capacity of 4,000 eggs, over which is a demonstration building; a pipe brood house (open-pipe system), 14 by 72 feet, which will accommodate 1,200 chickens; a long laying house, 14 by 180 feet, which accommodates 500 layers and furnishes facilities for student work in pen management; a

laboratory, 14 by 80 feet, for killing, picking, dressing, crate fattening, cramming, etc.; a storage building, 28 by 42 feet, for experimental incubation, poultry carpentry, poultry mechanics and storage; an experimental breeding house, 18 by 60 feet; the 6 old experiment station buildings, each 12 by 18 feet, to be used as breeding houses; 14 colony houses, 18 by 30 feet; 8 growing crops; a manure shed, 14 by 18 feet; and an oil house, 10 by 12 feet. Instruction in this department is given in the form of lectures, demonstrations and practical work. The practical work consists of poultry carpentry, caponizing, killing, picking, dressing, packing and selling poultry; pen management and fattening; running incubators and brooders, etc. At present the stock consists of 20 leading varieties of poultry. The aim of the department is to keep good specimens of all the most popular varieties of chicken, ducks and geese, so that a thorough course in poultry judging may be given, and that visitors may find the inspection of our stock an education in itself.

Public Speaking. — In connection with the work in public speaking, three regular contests are held during the year. The Burnham contest in declamation is open to freshmen and sophomores; the Flint contest in oratory and the annual debating contest are open (under restrictions) to all regular students. These contests furnish a very practical and necessary experience to all students interested in improving themselves in the art of public speaking. Prizes are given for excellence in the contests. Intercollege contests are arranged by the Public Speaking Council. One credit is given, except to freshmen, for a year of work in the College Debating Club.

Veterinary Science. — The department of veterinary science occupies a modern laboratory and hospital stable, built in accordance with the latest principles of sanitation. Every precaution has been taken in the arrangement of details to prevent the spread of disease, and to provide for effective heating, lighting, ventilation and disinfection.

The main building contains a large working laboratory for student use, and several small private laboratories for special work. There are a lecture hall, a museum, a demonstration room, a photographing room and a work shop. The hospital stable contains a pharmacy, an operating hall, a post-mortem and dissecting room, a poultry section, a section for cats and dogs, and 6 sections, separated from each other, for horses, cattle, sheep and swine. The laboratory equipment consists of a dissectible Auzoux model of the horse and Auzoux models of the foot and the leg, showing the anatomy and the diseases of every part. The laboratories also have modern, high-power microscopes, microtomes, incubators and sterilizers, for work in every department of veterinary science including pathology, serology and parasitology. There are skeletons of the horse, the cow, the sheep, the dog and the pig, and a growing collection of anatomical and pathological specimens. The lecture room is provided with numerous maps, charts and diagrams.

Zoölogy. — The college offers increased facilities for the study of Zoölogy. In the new building for entomology, zoölogy and geology are capacious laboratories for both undergraduate and graduate work. On the first floor is a large sophomore laboratory, 27 by 100 feet, with a present seating capacity of 100 persons. Adjoining this is a smaller room, 20 by 27 feet, for junior and senior courses. On the second floor is a laboratory, 20 by 32 feet, for advanced work. All laboratories are equipped with gas. The equipment consists of 80 compound microscopes and accessories, 70 dissecting microscopes,

microtomes and accessories, paraffine baths, incubator, dissecting instruments, glassware and other necessary apparatus.

The large amphitheater lecture hall is used jointly by the departments of entomology and zoölogy-geology. It is equipped with charts and models. The zoölogical museum is drawn upon at all times for illustrative material. The zoölogical museum is 27 by 48 feet. The main room is on the first floor of the building. Above this, on a level with the second floor, is a large gallery. On the main floor are 8 large wall cases and 5 large floor cases for exhibition purposes. The gallery has 1 large wall case and 3 floor cases with space for 9 additional cases. The zoölogical collection consists of nearly 12,000 specimens. All the chief phyla are represented. Adjoining the museum is a preparator's room for the curator. The museum is open to the public from 1 to 5 P.M. on Saturdays, and on other week days from 3 to 6 P.M. The curator is Associate Professor Gordon.

PRIZES AND AWARDS, 1913.

Grinnell Prizes. — The Grinnell prizes, given by the Hon. William Claflin of Boston in honor of George B. Grinnell, Esq., of New York to those members of the senior class who pass the best, second best and third best examinations, oral and written, in theoretical and practical agriculture, were awarded as follows: —

First prize, $25, awarded to Allister Francis McDougall.

Second prize, $15, awarded to Stuart Dodds Samson.

Third prize, $10, awarded to Ralph Hicks Gaskill.

Botanical Prizes. — The Hills prizes, given by Henry F. Hills of Amherst; no competition in 1913.

General Improvement. — The Western Alumni Association prize, given to that member of the sophomore class who during his first two years in college has shown the greatest improvement in scholarship, character and example, was awarded as follows: —

Twenty-five dollars to Waldo Atwood Cleveland.

Public Speaking. — The Burnham prizes, given to the students delivering the best and second best declarations, were awarded as follows: —

First prize, $15, awarded to Henry Hyman Kitsis.

Second prize, $10, awarded to Irving Boin Lincoln.

The Flint prizes, given to the students delivering the best and second best orations, were awarded as follows: —

First prize, a gold medal and $20, awarded to Irving Boin Lincoln.

Second prize, $15, awarded to Frederick David Griggs.

Debating. — The prizes in the annual debate were awarded as follows: —

Fifteen dollars and gold medal, awarded to Herbert Augustine Brown.

Fifteen dollars and gold medal, awarded to Frederick William Read.

Fifteen dollars and gold medal, awarded to Charles Holt Gould.

The prizes in the interclass debate were awarded as follows: —

To the team representing the Class of 1916, consisting of Thomas Lincoln Harrocks, Charles Holt Gould and Perez Simmons. This team was awarded a silver cup.

Military Honors. — The following-named cadet officers were reported to the Adjutant-General of the United States army and to the Adjutant-

General of the Commonwealth of Massachusetts, being efficient in military science and tactics and graduating therein with highest honors: —

Cadet Colonel James Dudley French.
Cadet Major Albert Joseph Kelly.
Cadet Major Norman Russell Clark.
Cadet Captain Albert Franklin Edminster.
Cadet Captain John Lawrence Mayer.
Cadet Captain Allister Francis McDougall.

The prize of $100, offered by the New York, New Haven & Hartford Railroad to that student of the Massachusetts Agricultural College, who, during the school year 1912–13, should make the best suggestion of a method by which our system of railroads can co-operate with the Massachusetts Agricultural College for the development of the agricultural possibilities of Massachusetts in particular and New England in general, was awarded to Chester King Allen.

SECRETARIES OF ALUMNI ASSOCIATIONS.

Alumni Secretaries' Association of the Massachusetts Agricultural College.
Secretary: Ralph J. Watts, 1907, Amherst, Mass.

Associate Alumni of the Massachusetts Agricultural College.
Secretary: Charles A. Peters, 1897, Amherst, Mass.

Alumni Club of Massachusetts.
Clerk: H. Linwood White, 1909, 136 State House, Boston, Mass.

Connecticut Valley Association of the Massachusetts Agricultural College.
Secretary: Charles L. Brown, 1894, 870 State Street, Springfield, Mass.

Massachusetts Agricultural College Club of New York.
Secretary: John Ashburton Cutter, 1882, 262 West 77th Street, New York, N. Y.

Massachusetts Agricultural College Club of Washington, D. C.
Secretary: Clarence H. Griffin, 1904, 1864 Park Road, Washington, D. C.

Western Alumni Association of the Massachusetts Agricultural College.
Secretary: Charles A. Tirrell, 1906, 4012 Perry Street, Chicago, Ill.

Massachusetts Agricultural College Pacific Coast Alumni Association.
Secretary: Thomas F. Hunt, 1905, Berkeley, Cal.

Class Secretaries.

Class of	Secretary.	Secretary's Address.
1871	E. E. Thompson, .	5 Jacques Avenue, Worcester, Mass.
1872	F. E. Kimball, . .	8 John Street, Worcester, Mass.
1873	C. Wellington, . .	Amherst, Mass.
1874	D. G. Hitchcock, . .	Warren, Mass.
1875	M. Bunker, . .	Newton, Mass.
1876	C. Fred Deuel, . .	Amherst, Mass.
1877	Atherton Clark, . .	Newton, Mass.
1878	C. O. Lovell, . .	5 Bromfield Street, Boston, Mass.
1879	R. W. Swan, . .	41 Pleasant Street, Worcester, Mass.
1880	Alvan Fowler, . .	413 Post Office Building, Philadelphia, Pa.
1881	J. L. Hills, . . .	59 North Prospect Street, Burlington, Vt.
1882	G. D. Howe, . .	25 Winter Street, Bangor, Me.
1883	J. B. Lindsey, . .	Amherst, Mass.
1884	– –	– –
1885	E. W. Allen, . .	1923 Biltmore Street, Washington, D. C.
1886	Dr. Winfield Ayres, .	616 Madison Avenue, New York City.
1887	F. H. Fowler, . .	Shirley, Mass.
1888	H. C. Bliss, . .	14 Mechanic Street, Attleborough, Mass.
1889	C. S. Crocker, . .	1003 South 25th Street, Philadelphia, Pa.
1890	David Barry, . .	398 Walnut Street, Newtonville, Mass.
1891	H. T. Shores, . .	177 Elm Street, Northampton, Mass.
1892	H. M. Thompson, .	Amherst, Mass.
1893	F. A. Smith, . .	Turner Hill, Ipswich, Mass.
1894	S. F. Howard, . .	Amherst, Mass.
1895	E. A. White, . .	Ithaca, N. Y.
1896	A. S. Kinney, . .	South Hadley, Mass.
1897	C. A. Peters, . .	Amherst, Mass.
1898	– –	– –
1899	D. A. Beaman, . .	Rio Piedras, Porto Rico.
1900	E. K. Atkins, . .	15 Hubbard Avenue, Northampton, Mass.
1901	J. H. Chickering, .	Dover, Mass.
1902	H. L. Knight, . .	1420 Buchanan Street, Washington, D. C.
1903	G. D. Jones, . .	North Amherst, Mass.
1904	P. F. Staples, . .	North Grafton, Mass.
1905	A. D. Taylor, . .	1101 Tremont Building, Boston, Mass.
1906	Richard Wellington, .	Geneva, N. Y.
1907	Clinton King, . .	6 Beacon Street, Boston, Mass.
1908	J. A. Hyslop, . .	860 North Mulberry Street, Hagerstown, Md.
1909	O. B. Briggs, . .	1015 Fidelity Building, Baltimore, Md.
1910	F. L. Thomas, . .	Amherst, Mass.
1911	L. M. Johnson, . .	Newtown, Conn.
1912	F. S. Madison, . .	East Greenwich, R. I.
1913	B. W. Ellis, . .	Segreganset, Mass.

Degrees Conferred and Roll of Students.

Degrees Conferred — 1913.

Master of Science.

Watkins, John Bedford, Midlothian, Va. Virginia Polytechnic, B.Sc., 1911.

Bachelor of Science (B.Sc.).

Adams, Winford Frederick,	East Leverett.
Allen, Harry Willis,	West Pelham.
Anderson, Oscar Gustaf,	East Pepperell.
Angier, Harris William,	Westborough.
Baird, Harry Albert,	Somerville.
Baker, Dean Foster,	Fairhaven.
Barber, George Ware,	Hyde Park.
Bevan, Laurence Algur,	Newtonville.
Birdsall, Webster Jennings,	Otego, N. Y.
Borden, Ralph James,	Fall River.
Brewer, Charlesworth Herbert,	Mt. Vernon, N. Y.
Brown, Herbert Augustine,	Saxonville.
Bullard, Alvan Henry,	South Framingham.
Burby, Lawrence Walter,	Chicopee Falls.
Bursley, Harold Barrows,	Peabody.
Carver, John Stuart,	Roslindale.
Clark, Norman Russell,	Millbury.
Cobb, Joseph Boyd,	Chicopee Falls.
Cole, Arlin Tower,	West Chesterfield.
Cole, Flora Atwood,	Newton.
Coleman, Isaac,	Amherst.
Cooper, Everett Hanson,	Greenwood.
Cory, Harold,	Rutherford, N. J.
Covill, Joseph Warren,	Roxbury.
Cristman, Clyde Edward,	Dalton.
Culley, Frank Hamilton,	Marshalltown, Ia.
Curtis, Harold William,	Belchertown.
Daniel, Edward Stephen Coen,	Osterville.
Dayton, James Wilson,	Georgetown, Conn.
Dooley, Thomas Patrick,	South Boston.
Drury, Lewis Floyd,	Rutland.
Edminster, Albert Franklin,	Brooklyn, N. Y.
Eisenhaure, John Louis,	North Reading.
Ellis, Benjamin Ward,	Plymouth.
Ells, Gordon Waterman,	Haverhill.
Fay, Robert Sedgwick,	Monson.
Forbush, Wallace Clifford,	Rutland.
French, James Dudley,	Hyde Park.
Gaskill, Ralph Hicks,	Amherst.
Gore, Harold Martin,	Wollaston.
Greenleaf, George Freeman,	Brockton.
Griggs, Frederick David,	Chicopee Falls.
Harris, Burton Adams,	Wethersfield, Conn.
Hasey, Willard Harrison,	Campello.
Hatch, Herbert Tilden,	Atlantic.
Headle, Herbert Wallace,	Bolton.
Headle, Marshall,	Bolton.

Holden, James Loomis,	Palmer.
Howe, Glover Elbridge,	Marlborough.
Howe, Ralph Wesley,	East Dover, Vt.
Huntington, Samuel Percy,	Lynn.
Hutchings, Herbert Colby,	South Amherst.
Hyland, Harold Wilson,	Weymouth.
Jones, Harold Frederic,	Campello.
Jordan, Simon Miller,	Rutherford, N. J.
Kelley, Albert Joseph,	Roxbury.
Kelley, Bernard Jenkins,	Harwichport.
Kenney, Frederick Alfred,	Charlestown.
Larsen, Nils Paul,	Bridgeport, Conn.
Lesure, John Warren Thomas,	Fitchburg.
Little, Willard Stone,	Newburyport.
Lowry, Quincy Shaw,	Canton.
Lyon, Harold,	Somerville.
Macone, Joseph Augustine,	Concord.
Mallett, George Alfred,	Bridgeport, Conn.
Matz, Julius,	Lynn.
Mayer, John Lawrence,	South Boston.
McDougall, Allister Francis,	Westford.
Moir, William Stuart,	Boston.
Murray, Joseph Wilbur,	Holyoke.
Neal, Ralph Thomas,	Mattapan.
Nichols, Norman Joseph,	Everett.
O'Brien, James Leo,	Wayland.
Packard, Clyde Monroe,	Springfield.
Pease, Lester Newton,	Meriden, Conn.
Pillsbury, Joseph James,	West Bridgewater.
Post, George Atwell,	Richmond Hill, N. Y.
Roehrs, Herman Theodore,	New York, N. Y.
Samson, Stuart Dodds,	Grand Isle, Vt.
Selden, John Lincoln,	Northampton.
Serex, Paul, Jr.,	Jamaica Plain.
Sheehan, Dennis Anthony,	South Lincoln.
Shute, Carl August,	Quincy, Ill.
Streeter, Charles Marsh,	Brimfield.
Thayer, Clark Leonard,	Smith's.
Tucker, Waldo Guy,	Lynn.
Van Zwaluwenburg, Reyer Herman,	Rutherford, N. J.
Walker, Charles Dexter,	Greenwich Village.
Whitney, Francis Wellington,	Wellesley.
Zabriskie, George, 2d,	New York, N. Y.

Graduate Students — Candidates for a Degree.

Ackerman, Arthur John,	Worcester.
B.Sc., Massachusetts Agricultural College, 1912.	
Baird, Charles Glenn,	Cedar Rapids, Neb.
A.B., University of Kansas, 1911: A.M., University Wyoming, 1913.	
Beals, Carlos Loring,	Sunderland.
B.Sc., Massachusetts Agricultural College, 1912.	
Bogue, Robert H.,	North Amherst.
B.Sc., Tufts, 1912.	
Bourne, Arthur Isreal,	Kensington, N. H.
A.B., Dartmouth, 1907.	
Brown, Adrian Abbott,	Waterloo, Wis.
B.Sc., in Agriculture, University of Wisconsin, 1912.	
Brown, Henry Leavitt,	Ayer.
B.Sc., University of Maine, 1913.	
Copson, Godfrey Vernon,	Grand Rapids, Mich.
B.Sc., in Agriculture, Oregon Agricultural College, 1911.	
Davies, Ernest Langford,	Toronto, Can.
B.Sc., in Agriculture, Toronto University, 1913.	

Fiske, Raymond John, ... Stoneham.
B.Sc., Massachusetts Agricultural College, 1910.
Fowler, George Scott, ... Wayland.
B.Sc., Massachusetts Agricultural College, 1912.
Georgia, Bert Cyrenius, ... Ithaca, N. Y.
B.Sc., Cornell University, 1913.
Hillary, Walter Hoxie, ... Philadelphia, Pa.
B.S., Pennsylvania State College, 1913.
Holland, Edward Bertram, ... Amherst.
M.S., 1892, Massachusetts Agricultural College.
Hutson, John Coghlan, ... Bridgetown, Barbados.
B.A., Oxford University, England, 1909.
Itano, Arao, ... Okayamaken, Japan.
B.Sc., Michigan Agricultural College, 1911.
Lund, Russell Fort, ... West Pelham.
B.A., St. Lawrence University, 1909.
Mackan, Charles R., ... Portsmouth, Va.
B.S., Virginia Polytechnic, 1911.
McLaughlin, Frederick Adams, ... Lee.
B.Sc., Massachusetts Agricultural College, 1911.
Martin, James Francis, ... Amherst.
B.Sc., Massachusetts Agricultural College, 1912.
Norton, John Buck, ... Hartford, N. Y.
B.Sc., University of Vermont, 1913.
Noyes, Harry Alfred, ... Lafayette, Ind.
B.S., 1912, Massachusetts Agricultural College.
Parker, Ralph Robinson, ... Penikese.
B.Sc., Massachusetts Agricultural College, 1912.
Robinson, Harold Averill, ... Elmwood, N. H.
B.Sc., New Hampshire State College, 1913.
Ruprecht, Rudolph William, ... Brooklyn, N. Y.
B.Sc., Rhode Island Agricultural College, 1911.
Sanctuary, William Crocker, ... Amherst.
B.Sc., Massachusetts Agricultural College, 1912.
Serex, Paul, Jr., ... Bloomfield, N. J.
B.Sc., Massachusetts Agricultural College, 1913.
Shoeman, Nichols Henry, ... Cesaria, Turkey.
Harpoot, Turkey, Euphrates College, 1907.
Smith, Raymond Goodale, ... Lynn.
B.Sc., Massachusetts Agricultural College, 1911.
Smulyan, Marcus Thomas, ... Amherst.
B.Sc., Massachusetts Agricultural College, 1909.
Strand, Carl John, ... Brattleboro, Vt.
A.B., Augustana College, 1907; M.A., University Illinois, 1908.
Thayer, Clark Leonard, ... Enfield.
B.Sc., Massachusetts Agricultural College, 1913.
Thomas, Frank Lincoln, ... Athol.
B.Sc., Massachusetts Agricultural College, 1910.
Tower, Daniel Gordon, ... Roxbury.
B.Sc., Massachusetts Agricultural College, 1912.

GRADUATE STUDENTS — CANDIDATES FOR NO DEGREE.

Chamberlain, Edwin Martin, ... Cambridge.
A.B., Harvard, 1911.
Martindale, Henrietta, ... LaCrosse, Wis.
A.B., Smith, 1913.
McBurney, Henry, ... Amherst.
B.S., Massachusetts Institute Technology.
Patton, Hamilton, ... Highland Park, Ill.
B.A., Amherst, 1913.
Toppan, Cushing, ... Cambridge.
A.B., Harvard, 1908.
Whittier, Warren Faxon, ... Amherst.
A.B., Harvard, 1909.
Wright, David Sanderson, ... Northampton.
B.A., Amherst College, 1909.

Roll of Students.

Senior Class.

Abbott, Leslie Elmer,	Sandwich,	10 North College.
Allen, Carl Murdough,	Holyoke,	16 South College.
Baker, Warren Sears,	Wollaston,	9 South College.
Black, Harold Cotting,	Falmouth,	96 Pleasant Street.
Blake, Ralph Cedric,[1]	Wollaston,	6 South College.
Bokelund, Chester Story,[1]	Worcester,	2 South College.
Bradley, John Watling,	Groton,	3 South College.
Bragg, Ralph Stanley,[1]	Milford,	96 Pleasant Street.
Brewer, Harold William,[1]	Mount Vernon, N. Y.,	1 South College.
Brooks, Arthur Winslow,	Smith's,	4 South College.
Brown, Harry Dunlap,	Lowell,	96 Pleasant Street.
Calvert, Melville Bradford,	New London, Conn.,	1 North College.
Campbell, Malcolm David,[1]	Still River,	3 North College.
Christie, Edward Wheeler,	North Adams,	2 North College.
Churchill, George Clarence,	Worcester,	58 Pleasant Street.
Clark, Ernest Samuel, Jr.,	Tolland,	15 North College.
Clay, Harold Johnson,	Cambridge,	16 South College.
Clegg, Frank Jackson,[1]	Fall River,	1 South College.
Coleman, David Augustus,	South Framingham,	3 North College.
Davies, Lloyd Garrison,	Peabody,	14 South College.
Davis, Ralph Edward,	Southbury, Conn.,	13 North College.
Davis, William Ashmun,	Northfield,	11 North College.
Dearing, Newton Howard,[1]	Brookline,	8 South College.
Dexter, Evans King,[1]	Mattapoisett,	Tower.
Dunbar, Erving Walker,	North Weymouth,	116 Pleasant Street.
Edgerton, Almon Morley,	Mittineague,	12 South College.
Edwards, Edward Clinton,[1]	North Beverly,	16 South College.
Eldridge, Harold Lockwood,[1]	Wareham,	Tower.
Foster, Stuart Brooks,[1]	West Somerville,	96 Pleasant Street.
Freeborn, Stanley Barron,	Ware,	10 South College.
Freedman, Samuel Leavitt,[1]	Roxbury,	12 North College.
Frye, Carl Raymond,[1]	South Hadley Falls,	Kappa Gamma Phi.
Fuller, George,	Deerfield,	19 Phillips Street.
Hadfield, Harold Frederic,	North Adams,	Kappa Gamma Phi.
Handy, Ralph Ellis,	Cataumet,	10 North College.
Harris, Rodney Wells,	Wethersfield, Conn.,	87 Pleasant Street.
Hazen, Edward Leonard,	Springfield,	96 Pleasant Street.
Hebard, Emory Blodgett,	Holland,	14 North College.
Heffron, Frederick,	Sherborn,	4 North College.
Hill, Charles Chase,[1]	Melrose Highlands,	Pease Avenue.
Hogg, Lawrence Jager,[1]	Lawrence,	9 North College.
Howard, Lewis Phillips,	North Easton,	16 North College.
Hutchinson, John Gouverneur,	Arlington,	14 South College.
Ingham, Earl Morris,	Granby,	19 Phillips Street.
Jacobs, Loring Humphrey,[1]	Wellesley,	25 Pleasant Street.
Jenny, Herbert Hedge,[1]	South Boston,	6 Nutting Avenue.
Jones, Dettmar Wentworth,[1]	Melrose,	10 South College.
Leete, Richard Fowler,	Mt. Kisco, N. Y.,	81 Pleasant Street.

[1] Work incomplete.

Levine, Henry Walter,[1]	Roxbury,	12 North College.
Lincoln, Murray Danforth,	Raynham,	16 North College.
Lucas, Hoyt Dennis,	Springfield,	8 Allen Street.
Major, Joseph,	East Rutherford, N. J.,	58 Pleasant Street.
Marsh, Frank Eugene,[1]	Jefferson,	90 Pleasant Street.
Merkle, Frederick Grover,	Amherst,	North East Street.
Morrison, Harold Ivory,	Melrose,	66 Pleasant Street.
Morse, Harold John,	Townsend,	3 South College.
Needham, Lester Ward,	Springfield,	96 Pleasant Street.
Nicolet, Theodore Arthur,[1]	Fall River,	85 Pleasant Street.
Nicolet, Tell William,	Fall River,	85 Pleasant Street.
Nissen, Harry,	Boston,	85 Pleasant Street.
Norton, Leslie Howard,	Newport, R. I.,	4 South College.
Nute, Raymond Edson,	Fall River,	North College.
O'Brien, Daniel William,[1]	Wayland,	6 North College.
Oertel, John Thomas,[1]	South Hadley Falls,	116 Pleasant Street.
Parker, Ervine Franklin,[1]	Poquonock, Conn.,	96 Pleasant Street.
Payne, Roland Alfred,	Wakefield,	North Amherst.
Pellett, John Doubleday,	Worcester,	3 South College.
Peters, Chester Harry,	Clinton,	Physics Building.
Petersen, Peveril Oscar,	Concord,	4 North College.
Porter, Bennett Allen,	Amherst,	11 North College.
Powers, Richard Henry,[1]	Malden,	7 South College.
Read, Frederick William,	Boston,	2 South College.
Reid, George Alexander,[1]	Worcester,	French Hall.
Russell, Alden Hesseltine,	Watertown,	14 North College.
Sahr, Gabriel William Arthur,[1]	Boston,	15 Phillips Street.
Sherman, Joel Powers,	Hyannis,	8 South College.
Small, Francis Willard,	North Truro,	Flint Laboratory.
Smith, Leon Edgar,	Boston,	85 Pleasant Street.
Smith, Leone Ernest,	Leominster,	15 North College.
Stevens, Arthur Eben,	Lawrence,	South College.
Strange, Sarah Josephine,	Marshfield,	Draper Hall.
Tarbell, Munroe Gifford,	Brimfield,	10 North College.
Taylor, Arthur Wright,[1]	Feeding Hills,	116 Pleasant Street.
Taylor, Leland Hart,	Peabody,	15 South College.
Thurston, Arthur Searle,	Everett,	Beta Kappa Phi.
Tower, Alfred Leigh,	Sheffield,	Entomological Building.
Tupper, Arthur Somerville,[1]	Roxbury,	85 Pleasant Street.
Upton, Ernest Franklin,[1]	Salem,	13 South College.
Walker, Nathaniel Kennard,	Malden,	88 Pleasant Street.
Walker, Raymond Philip,	Taunton,	88 Pleasant Street.
Warner, Raymond Winslow,	Sunderland,	9 South College.
Webster, Louis Armstrong,	Blackstone,	16 North College.
Weigel, Arthur George,	Lawrence,	9 North College.
Wheeler, Chester Eaton,	Lowell,	87 Pleasant Street.
Whidden, Burton Clark,	Lowell,	81 Pleasant Street.
Whippen, Charles Warren,	Lynn,	2 North College.
Wing, John Govan,	Somerville,	116 Pleasant Street.
Wood, Henry Joseph,	Mendon,	82 Pleasant Street.

Junior Class.

Alden, Charles Harold,[1]	Amherst,	East Pleasant Street.
Allen, Francis Ellwood,	Melrose,	10 Allen Street.
Anderson, Herbert Henry,	Ware,	5 Nutting Avenue.
Archibald, Herbert Hildreth,	Waltham,	11 South College.
Banister, Seth Warrener,[1]	Westford,	82 Pleasant Street.
Bartlett, Edward Russell,	Newburyport,	3 Nutting Avenue.
Bartley, Hastings Newcomb,[1]	Sandwich,	6 South College.
Bemis, Willard Gilbert,[1]	North Brookfield,	12 Cottage Street.
Bennett, John Ingram,[1]	Dorchester,	66 Pleasant Street.

[1] Work incomplete.

Bishop, Chester Allen,[1]	Peterboro, N. H.,	85 Pleasant Street.
Brooks, Gardner Milton,[1]	Boston,	8 Allen Street.
Buell, Frank Weed,[1]	Clinton, Conn.,	5 South College.
Buttrick, John Willard,	Melrose,	18 Nutting Avenue.
Cale, Gladstone Hume,	Springfield,	Beta Kappa Phi.
Cande, Donald Hopkins,[1]	Pittsfield,	87 Pleasant Street.
Chase, Alexander Baxter, Jr.,	West Barnstable,	Clark Hall.
Clark, Ellis Fred,	Granby, Conn.,	North College.
Cleveland, Waldo Atwood,[1]	Baldwinsville,	Veterinary Laboratory.
Clough, Maurice Joseph,[1]	Boston,	7 South College.
Cole, Herbert Elmer,[1]	Manchaug,	Plant House.
Dalrymple, Andrew Campbell,	Revere,	3 McClellan Street.
Damon, Leon Blanchard,[1]	Melrose,	18 Nutting Avenue.
Day, George Allen,[1]	Warren,	12 Cottage Street.
Dole, Sumner Alvord,	Bardwell's Ferry,	11 North College.
Donnell, George Edwin,	Burlington,	East Experiment Station.
Doran, William Leonard,	North Dartmouth,	Beta Kappa Phi.
Draper, Earle Sumner,	Milford,	85 Pleasant Street.
Farrar, Stuart Kittredge,[1]	Springfield,	96 Pleasant Street.
Fitzgerald, Daniel James,[1]	Worcester,	Kappa Gamma Phi.
Flebut, Alpha John,	Amherst,	27 McClellan Street.
Frost, Robert Theodore,[1]	New York, N. Y.,	85 Pleasant Street.
Fuller, Richard,[1]	Salem,	16 South College.
Goodwin, Malcolm Noyes,	Newburyport,	96 Pleasant Street.
Grant, Harold Davidson,	Methuen,	3 McClellan Street.
Griggs, Raymond Bradford,[1]	Chicopee Falls,	15 South College.
Hall, George Morris,[1]	Brookline,	85 Pleasant Street.
Hall, Roderick Chesley,	Worcester,	Beta Kappa Phi.
Harper, James Edward,[1]	New Haven, Conn.,	Kappa Gamma Phi.
Harvey, Russell Wilton,[1]	Lanesville,	44 Pleasant Street.
Haskell, Willis Henry, Jr.,[1]	Brooklyn, N. Y.,	116 Pleasant Street.
Hatfield, William Hollis,[1]	Wellesley,	87 Pleasant Street.
Hildreth, Paul Hughes,[1]	Newtonville,	12 South College.
Hotis, Ralph P.,	Evans Mills, N. Y.,	21 Amity Street.
Hyde, George Frederick,	North Dana,	Beta Kappa Phi.
Hyde, Harold Gilmore,	Winchendon,	36 North Prospect Street.
Johnson, Arthur,	Bridgeport, Conn.,	7 South College.
Johnson, Rollin Eugene,[1]	Templeton,	6 Phillips Street.
Kelleher, Jerome Joseph,	Montague City,	75 Pleasant Street.
Kennedy, Worthington Chester,	Hardwick,	6 North College.
Lane, Merton Chesleigh,	South Duxbury,	Mathematics Building.
LeDuc, Ashley Cudworth,	Chesterfield,	5 Nutting Avenue.
Lewis, Daniel James,	Hanson,	96 Pleasant Street.
Lewis, John Kirby,	New Haven, Conn.,	Care of Mr. E. M. Dickinson.
Lincoln, Irving Boin,[1]	Glens Falls, N. Y.,	94 Pleasant Street.
Lovejoy, John Sumner,[1]	Newburyport,	53 Lincoln Avenue.
MacNeil, Ralph Langdel,[1]	Chelsea,	52 Amity Street.
Macy, Philip Arthur,[1]	Oak Bluffs,	53 Lincoln Avenue.
Marsh, Franklin Winter,[1]	Amherst,	18 Nutting Avenue.
Marsh, Herbert Vener,	Deerfield,	Beta Kappa Phi.
Masse, Sidney Merton,[1]	Dorchester,	6 Nutting Avenue.
McKechnie, Ray Farrar,[1]	Natick,	Kappa Gamma Phi.
McLain, Ralph Emerson,[1]	Melrose,	5 South College.
Melican, George Deady,[1]	Worcester,	75 Pleasant Street.
Moberg, Eldon Samuel,[1]	Campello,	7 North College.
Montague, Enos James,	Northampton,	North College.
Moore, Roger Henry,[1]	Beverly,	6 Nutting Avenue.
Navas, Miguel,[1]	Barranquilla, Col., S. A.,	6 Phillips Street.
Parker, Edwin Kenney,[1]	Northampton,	East Experiment Station.
Parmenter, Ernest Brigham,[1]	Dover,	Beta Kappa Phi.
Patterson, Robert Earley,[1]	Dorchester Center,	75 Pleasant Street.
Pendleton, Harlow Libby,[1]	Dorchester,	Flint Laboratory.

[1] Work incomplete.

Perry, Gerald Eugene,	Amherst,	17 Amity Street.
Pike, Joseph Stevens, Jr.,[1]	Somerville,	3 Nutting Avenue.
Potter, George Raymond,[1]	Ludlow,	44 Pleasant Street.
Price, James Albert,	New York, N. Y.,	11 South College.
Rhoades, Paul Whitney,[1]	Malden,	66 Pleasant Street.
Rogers, Harold Merriman,	Southington, Conn.,	87 Pleasant Street.
Sauchelli, Vincent,	Waterbury, Conn.,	11 High Street.
Sears, William Richard,	Woburn,	6 South College.
Severance, Verne Lincoln,	South Hanson,	Mathematics Building.
Sherman, Milton Francis,	South Lincoln,	10 Allen Street.
Simon, Isaac Barney,	Revere,	38 Cottage Street.
Slein, Owen Francis,	New Braintree,	127 South Pleasant Street.
Smith, Hyde,[1]	Worcester,	12 North College.
Spicer, Eber Grant,	Poughkeepsie, N. Y.,	44 Triangle Street.
Spofford, Chester Porter,[1]	Georgetown,	Kappa Gamma Phi.
Taft, Richard Craig,[1]	Oxford,	88 Pleasant Street.
Tarr, Lester Winslow,	Rockport,	Beta Kappa Phi.
Tower, Ralph Ernest,	Becket,	120 Pleasant Street.
Tower, William Reginald,	Sheffield,	94 Pleasant Street.
Towne, Edwin Chester,[1]	Waltham,	85 Pleasant Street.
Upton, Raymond Melville,	Peabody,	Plant House.
Vener, Benjamin,	Brockton,	38 Cottage Street.
Vinal, Stuart Cunningham,	Boston,	8 Allen Street.
Wellington, Benjamin,	Waltham,	15 Phillips Street.
White, Henry Harrison,	West Peabody,	Beta Kappa Phi.
White, Homer Beethoven,[1]	Melrose Highlands,	Apiary.
Whitmore, Philip Ferry,	Sunderland,	88 Pleasant Street.
Whorf, Paul Francis,[1]	Boston,	87 Pleasant Street.
Wilkins, Alfred Emerson,[1]	Wakefield,	116 Pleasant Street.
Willey, Harold Cleland Clancey,[1]	Orange,	Plant House.
Williams, Donald,[1]	Catasauqua, Pa.,	85 Pleasant Street.
Wright, Elvin Stanley,	Worcester,	88 Pleasant Street.

Sophomore Class.

Aiken, Harold,	Millis,	42 McClellan Street.
Allen, Chester King,	Quincy,	82 Pleasant Street.
Anderson, Frank Albert,	Somerville,	13 Phillips Street.
Andrews, Francis Marshall, Jr.,[1]	Manchester,	53 Lincoln Avenue.
Baker, Roland Sears,[2]	Brooklyn, N. Y.,	- -
Barnes, Dwight Fletcher,[1]	Marshfield,	30 North Prospect Street.
Barnes, Fred Leslie,[1]	Plymouth,	Entomological Building.
Bartlett, Emory Haynes,	Boston,	12 Cottage Street.
Beeler, Leon Charles,[1]	Adams,	Kappa Gamma Phi.
Betsch, William Carter,[1]	New York, N. Y.,	60 Pleasant Street.
Bisbee, Philip Emerson,[1]	Waitsfield, Vt.,	1 South College.
Bishop, Herbert Walker,[1]	Doylestown, Pa.,	85 Pleasant Street.
Blanpied, Nelson Uhler,	Framingham,	M. A. C. Farm House.
Boyer, Edward Everett Hale,[1]	Lynn,	8 North Prospect Street.
Brazil, William Henry,	Leominster,	116 Pleasant Street.
Burt, Helen Francis,	West Somerville,	Draper Hall.
Caldwell, Harold Nute,[1]	Lowell,	M. A. C. Farm House.
Cardarelli, Emilio Joseph,	Boston,	West Experiment Station.
Carver, Frank Whitney,[1]	Plymouth,	Care of Professor Morton.
Cederstrom, Hjalmar,[2]	Dorchester,	- -
Chamberlin, Raymond,[1]	New York, N. Y.,	85 Pleasant Street.
Chase, Esther Helen,[1]	Holden,	Draper Hall.
Chisholm, Raymond Lincoln,	Melrose Highlands,	15 Beston Street.
Clapp, Raymond Luckey,	Northfield,	Care of Mr. Julian.
Clough, Charles Henry,[1]	Dedham,	15 Beston Street.
Coleman, Albert Sumner,[1]	Mendon,	82 Pleasant Street.
Coley, William Stanton,[1]	Wilton, Conn.,	87 Pleasant Street.

[1] Work incomplete.

[2] Entered in February, 1913, left September, 1913.

Courchene, Alcide Telesphor,[1]	North Adams,	Kappa Gamma Phi.
Curran, Harry Ambrose,	Marlborough,	Kappa Gamma Phi.
Curtin, Charles Warren,	Auburndale,	36 North Prospect Street.
Cushing, Raymond Alonzo,[1]	Somerville,	13 Phillips Street.
Danforth, George Newlin,[1]	Foxcroft, Me.,	96 Pleasant Street.
Darling, Homer Chester,	Mendon,	9 South College.
Davis, Frank Leslie,[1]	Hopedale,	North Pleasant Street.
Dickinson, William Cowls,	North Amherst,	North Amherst.
Dinsmore, Donald Sanderson,	Springfield,	88 Pleasant Street.
Dodge, Walter Eugene,	Geneva, O.,	14 Phillips Street.
Doggett, William Henry,	Dedham,	35 East Pleasant Street.
Duffill, Edward Stanley,[1]	Boston,	8 Allen Street.
Eldredge, Raymond Chase,	North Abington,	30 North Prospect Street.
Estes, Ralph Cary,	South Framingham,	116 Pleasant Street.
Fernald, Charles Henry, 2d,	Amherst,	44 Amity Street.
Fielding, Lester Edward,[1]	Malden,	96 Pleasant Street.
Fisher, George Basil,[1]	Millbury,	88 Pleasant Street.
Gaventa, Harry Reymer,	Swedesboro, N. J.,	Brooks Farm.
Gilmore, Benjamin Anthony,[1]	Acushnet,	40 Amity Street.
Gioiosa, Alfred Anthony,	Dorchester,	8 North College.
Glover, Theodore Whitford,[1]	South Duxbury,	Care of S. J. Wright.
Goodwin, Clinton Foster,	Haverhill,	82 Pleasant Street.
Googins, Burton,	Brooklyn, N. Y.,	96 Pleasant Street.
Gould, Charles Holt,	Worcester,	88 Pleasant Street.
Gunn, Carlton Merrick,	Sunderland,	Beta Kappa Phi.
Hager, Clayton Marden,	Winter Hill,	87 Pleasant Street.
Hall, Stanley William,	Saxonville,	Brooks Farm.
Harris, William Lombard, Jr.,	Deerfield,	53 Lincoln Avenue.
Harrocks, Thomas Lincoln,	Westminster,	21 Fearing Street.
Hart, Reginald,	Montague City,	53 Lincoln Avenue.
Haskell, Frank Eugene,	Northborough,	Mt. Pleasant.
Hathaway, Charles Edward, Jr.,[1]	Somerset,	87 Pleasant Street.
Hemenway, Justin Stanley,	Williamsburg,	Brooks Farm.
Hendry, Arthur Ekman,[1]	Milton,	18 Nutting Avenue.
Hicks, Albert James,[1]	Amherst,	Brooks Farm.
Holden, Mae Faustina,	Royalston,	President's House.
Hunt, Reginald Stuart,[1]	Bridgewater,	8 South Prospect Street.
Huntington, Charles Albert, Jr.,	Poquonock, Conn.,	96 Pleasant Street.
Jerome, Frederick William,[1]	Stockbridge,	40 Amity Street.
Jones, Linus Hale,[1]	Milford,	Care of Mr. Green.
Jordan, Perley Black,	Topsfield,	16 South College.
Kelly, Harold Russell,[1]	Haverhill,	11 Gaylord Street.
Kilbon, Ralph Gillette,[1]	Springfield,	Brooks Farm.
King, Edward Lee,	Dorchester,	8 South College.
Knapton, Guy Lord,	Lawrence,	Pease Avenue.
Laird, Kenneth Bradford,	Brockton,	Beta Kappa Phi.
Lamoureux, Domina Joseph,[1]	Adams,	Kappa Gamma Phi.
Lieber, Conrad Hugo,	Jamaica Plain,	Kappa Gamma Phi.
Lindquist, Albert Evert,[1]	Jamaica Plain,	Physics Laboratory.
Little, Harold Greenleaf,	Newburyport,	5 North College.
Locke, Wilbur Trow,	Lawrence,	36 North Prospect Street.
Lyford, Waldo Preston,[1]	Natick,	52 Lincoln Avenue.
Mahan, Harold Butterworth,[1]	Boston,	Kappa Gamma Phi.
Mahony, William John,[1]	Winthrop,	10 South College.
Mason, Julius Stevens,[1]	Hanover, N. H.,	77 Pleasant Street.
Mattoon, Harold Gleason,[1]	Pittsfield,	116 Pleasant Street.
McCulloch, Norman Estes,	Pawtucket, R. I.,	96 Pleasant Street.
Mooney, Raymond Alson,[1]	Plattsburgh, N. Y.,	6 Tilson Court.
Moses, Charles Wicker,	Ticonderoga, N. Y.,	96 Pleasant Street.
Moss, Earle Chester,[1]	Worcester,	83 Pleasant Street.
Mostrom, Harold Augustus,	North Middleborough,	Care of Mr. Watts.
Murphy, John William,	Beverly,	15 Beston Street.

[1] Work incomplete.

Nash, Clayton Wells,	South Weymouth,	5 Sunset Avenue.
Nicholson, James Thomas,[1]	Leominster,	116 Pleasant Street.
Noyes, Samuel Verne,	Georgetown,	Beta Kappa Phi.
O'Brion, Edwin Fulton,	Somerville,	31 North Prospect Street.
Palmer, George Bradford,	Brookline,	96 Pleasant Street.
Pease, Willard Noah Morris,[1]	Amherst,	Brooks Farm.
Perry, Edgar Adams,	Attleborough,	21 Amity Street.
Phelps, Sanford Wallace, Jr.,[1]	Turners Falls,	68 Pleasant Street.
Plaisted, Philip,	Arlington,	15 Beston Street.
Potter, David,	Concord,	40 Amity Street.
Pratt, Walter Howard,[1]	Dalton,	M. A. C. Farm House.
Prouty, Stanley Marshall,	North Brookfield,	96 Pleasant Street.
Ray, George Burrill,	Hingham,	Kappa Gamma Phi.
Reed, Andrew John, Jr.,[1]	Dalton,	M. A. C. Farm House.
Rich, Gilbert Warren,	Hingham,	Care of Professor Morton.
Richards, Everett Stackpole,	Northampton,	96 Pleasant Street.
Richardson, Lewis Elmer,[1]	Rockville,	42 McClellan Street.
Ricker, Dean Albert,	Worcester,	85 Pleasant Street.
Rogers, Tyler Stewart,	Saxonville,	M. A. C. Farm House.
Rowe, Louis Victor,[1]	Melrose,	18 Nutting Avenue.
Russell, Ernest Samuel,[1]	Hadley,	96 Pleasant Street.
Ryan, William Edward, Jr.,[1]	Stoughton,	52 Amity Street.
Sander, Benjamin Charles Louis,[1]	Cambridge,	Brooks Farm.
Sanderson, Everett Shovelton,	Centreville, R. I.,	Nutting Avenue.
Saunders, William Putman,	Lawrence,	116 Pleasant Street.
Sauter, William Hugo,[1]	Turners Falls,	60 Pleasant Street.
Scheufele, Frank Joseph,	South Natick,	15 Beston Street.
Schlotterbeck, Lewis,	Roxbury Station, Conn.,	85 Pleasant Street.
Schwartz, Louis,[1]	Melrose,	West Experiment Station.
Sherinyan, Suran Donald,	Worcester,	35 North Prospect Street.
Simmons, Perez,	Pittsfield,	21 Fearing Street.
Smith, Philip Lawrence,[1]	Kingston,	52 Amity Street.
Stanford, Ernest Elwood,	Amherst,	4 Walnut Street.
Stearns, Frederick Campbell,[1]	Birmingham, Ala.,	40 Amity Street.
Stoughton, Richard,[1]	Montague,	21 Fearing Street.
Strauss, Abraham,	Boston,	101 Pleasant Street.
Swan, Durelle,	Dorchester,	18 Nutting Avenue.
Taber, Ralph Fred,	Cooperstown, N. Y.,	Mt. Pleasant.
Tarbell, Herbert Hitchcock,	Warren,	88 Pleasant Street.
Topham, Alfred,	Lawrence,	116 Pleasant Street.
Upham, Thomas Carlton,	Fitchburg,	53 Lincoln Avenue.
Verbeck, Howard Graves,	Malden,	Care of Mr. Green.
Walkden, Herbert Halden,	Westford,	Brooks Farm.
Walker, Henry Marshall,[1]	Brookline,	Brooks Farm.
Wells, Harry Andrew,[1]	Dalton, Pa.,	75 Pleasant Street.
Wentworth, Everett Lawrence,	East Dover, Vt.,	Wilder Hall.
Wetherbee, Raymond Swift,	Waltham,	Beta Kappa Phi.
Whitney, Harold Tichenor,[1]	Mt. Vernon, N. Y.,	8 North College.
Whitney, Leon Bradley,	Brooklyn, N. Y.,	96 Pleasant Street.
Wies, Calmy,[1]	Malden,	38 Cottage Street.
Wilcox, Timothy Palmer,	Andover,	7 North College.
Wildon, Garrick Earl,[1]	Melrose Highlands,	66 Pleasant Street.
Zehrung, Samuel Danford,[1]	Roseville, O.,	120 Pleasant Street.

FRESHMAN CLASS.

Adams, Henry Leo,[1]	Newburyport,	Brooks Farm.
Alcott, William Jefferson,[1]	Everett,	25 Pleasant Street.
Andrews, Robert Morton,	South Carver,	88 Pleasant Street.
Armstrong, James,	North Adams,	–
Avery, Hazelton Small,[1]	San Juan, P. R.,	66 Pleasant Street.
Babcock, Philip Rodney,[1]	Lynn,	75 Pleasant Street.

[1] Work incomplete.

Baer, Richard Moorehead,	Wellesley Farms,	6 Phillips Street.
Barnes, Herbert Wesley,	Whitinsville,	31 North Prospect Street.
Behrend, Oswald,	Natick,	29 McClellan Street.
Bell, Alfred Whitney, Jr.,[1]	West Newton,	40 Amity Street.
Bevan, Kenneth Charles,	Newtonville,	31 East Pleasant Street.
Birchard, John Dickson,	Springfield,	83 Pleasant Street.
Boles, Robert Stewart,[1]	Dorchester,	67 Pleasant Street.
Bonn, Wesley Copeland,	Grafton,	5 Nutting Avenue.
Booth, Alfred,[1]	Middletown, N. Y.,	Care of Professor Morton.
Borden, Raymond Vincent,[1]	Fall River,	15 Fearing Street.
Bowen, David Jennings,	North East, Pa.,	12 Cottage Street.
Boyce, Harold Prescott,	Haverhill,	7 Nutting Avenue.
Boyd, Robert Lucius,[1]	Lynn,	Care of E. F. Gaskill.
Brainard, Dwight Gay,[1]	Dorchester,	35 East Pleasant Street.
Breck, Richard Winslow,[1]	Boston,	31 East Pleasant Street.
Breckenridge, Earl,	Lynn,	Care of E. F. Gaskill.
Brown, Frederick Ward,[1]	Scituate,	31 North Prospect Street.
Buchanan, Walter Gray,	Chicopee,	97 Pleasant Street.
Buck, Rollin Hugh,	Worcester,	56 Pleasant Street.
Buckman, Lewis Taylor,	Wilkes-Barre, Pa.,	Prospect House.
Burleigh, Arthur Leslie,[1]	Lynn,	75 Pleasant Street.
Buttrick, Herbert David,	Arlington,	79 Pleasant Street.
Cate, Rex March,	Faneuil,	3 Nutting Avenue.
Chamberlain, Sumner Fiske,[1]	Holden,	56 Pleasant Street.
Choate, Carlisle Edward,	Framingham,	53 Lincoln Avenue.
Clark, Walter Thompson,[1]	Granby,	120 Pleasant Street.
Cotton, Elwyn Page,	Woburn,	81 Pleasant Street.
Cross, Walter Irving,	Hingham,	53 Lincoln Avenue.
Davis, Monsell Henry,	Orange, N. J.,	Care of S. J. Wright.
Dawson, Harry Custer,	Tewksbury,	29 North Prospect Street.
Day, James Harold,	Hatfield,	Brooks Farm.
DeMerritt, Franklin,	Watertown,	3 Fearing Street.
DeMott, Harold Edward,[1]	Brooklyn, N. Y.,	50 Lincoln Avenue.
Dempsey, Paul Wheeler,	Dorchester,	53 Lincoln Avenue.
Dick, Robert Edmundston,	Barre,	– –
Dickey, Harold Gammell,	Dorchester Center,	18 Nutting Avenue.
Dizer, John Thomas,[1]	East Weymouth,	35 East Pleasant Street.
Doherty, Paul Edward,[1]	Fall River,	85 Pleasant Street.
Doll, Otto Henry,[1]	Adams,	35 East Pleasant Street.
Donovan, Frank Edward,	Turners Falls,	– –
Dowd, William Lawrence,	North Amherst,	North Amherst.
Dudley, Lofton Leland,	Long Branch,	36 North Prospect Street.
Dumas, Walter Branca,[1]	Boston,	35 East Pleasant Street.
Dunham, Henry Gurney,	West Bridgewater,	79 Pleasant Street.
Dunham, Kenneth Herbert,	North Bennington, Vt.,	34 North Prospect Street.
Dunn, Arthur Paul,	Malden,	35 East Pleasant Street.
Edwards, Francis Gill,	North Beverly,	13 South College.
Elliot, Ralph William,	Chartley,	12 Cottage Street.
Everbeck, George Charles,[1]	Winthrop,	25 Pleasant Street.
Farwell, Alfred Austin,	Turners Falls,	79 Pleasant Street.
Favor, Richard William,	Somerville,	29 North Prospect Street.
Fearing, Ralph Watson,[1]	Dorchester,	7 Nutting Avenue.
Ferris, Adaline Lawson,	Ridgefield Park, N. J.,	Draper Hall.
Flagg, Wayne McGrillis,	Mittineague,	116 Pleasant Street.
Flint, Oliver Simeon,	Lowell,	120 Pleasant Street.
Ford, Thomas Henry,[1]	Medford,	26 High Street.
Francis, Donald Smith,[1]	Athol,	35 North Prospect Street.
Freeborn, Theodore Merton,[1]	Fall River,	Brooks Farm.
French, Donald Lee,	Sandwich,	36 North Prospect Street.
Gamage, Carl Everett,[1]	East Lynn,	75 Pleasant Street.
Gillette, Glenn Councilman,[1]	Montague,	21 Fearing Street.
Goldstein, Maurice,	Lynn,	41 Pleasant Street.

[1] Work incomplete.

Graham, Leland Jenkins,	North Amherst,	North Amherst.
Gray, Milton Berford,	Woods Hole,	77 Pleasant Street.
Grayson, Emory Ellsworth,	Milford,	19 Nutting Avenue.
Griswold, Leon Swift,	Wethersfield, Conn.,	116 Pleasant Street.
Groff, Howard Clarkson,	Amherst,	197 South Pleasant Street.
Gurshin, Carl Alfred,[1]	Lynn,	35 North Prospect Street.
Gustetter, Ray Henry,	Hartford, Conn.,	14 Nutting Avenue.
Haaren, Paul,	Brooklyn, N. Y.,	31 East Pleasant Street.
Haglestein, Charles Henry,[1]	Dorchester,	66 Pleasant Street.
Hallett, Charles Hiram,	Mansfield,	M. A. C. Farm House.
Harlow, Frank Edward,	Malden,	77 Pleasant Street.
Harlow, Paul Goodhue,	Malden,	77 Pleasant Street.
Harrington, Albert Timothy,[1]	Lynn,	Care of E. F. Gaskill.
Harris, Warren Timothy,[1]	Millbury,	Brooks Farm.
Hartford, Claude Ernest,	Townsend,	Brooks Farm.
Hauck, Roland Manss,	Cincinnati, O.,	14 Nutting Avenue.
Heffron, Paul John,	Sherborn,	Care of S. J. Wright.
Henderson, Elliott,	Hingham,	35 East Pleasant Street.
Higginbotham, Harry,[1]	Taunton,	120 Pleasant Street.
Higgins, Gardner William,[1]	Norfolk,	42 McClellan Street.
Hill, Edmund Baldwin,[1]	Rutherford, N. J.,	3 Nutting Avenue.
Holden, Richard Lynde,	Milford, N. H.,	82 Pleasant Street.
Holder, Ralph Clifton,	Millis,	42 McClellan Street.
Holt, Francis Stetham,[1]	Cambridge,	3 Nutting Avenue.
Hooper, Albert Averill,	Lynn,	75 Pleasant Street.
Hubbell, Franklin Homer,	Westport, Conn.,	30 Prospect Street.
Huckins, Warren Israel,[1]	Sharon,	60 Pleasant Street.
Illman, Margaret Keble,	West Pelham,	West Pelham.
Irving, William Raymond,	Taunton,	120 Pleasant Street.
Jackson, Richmond Merrill,[1]	Georgetown,	36 North Prospect Street.
Joslyn, Elwyn Duane,	Northfield, Vt.,	7 Nutting Avenue.
Kautzenbach, Georg Johannes,[1]	Somerville,	31 North Prospect Street.
Keegan, Thomas Michael,[1]	Worcester,	88 Pleasant Street.
Kelsey, Lincoln David,	West Hartford, Conn.,	12 Cottage Street.
Kinsman, Alfred Oberlin, Jr.,	Merrimac,	46 McClellan Street.
Lancey, Clifford Scales,	Townsend,	79 Pleasant Street.
Landers, Giles Ezra,	Cataumet,	81 Pleasant Street.
Larson, Frederick Christian,	Everett,	26 High Street.
Latham, Paul Walker,	Norwich Town, Conn.,	66 Pleasant Street.
Lawrence, Milford Robinson,	Falmouth,	83 Pleasant Street.
Leigh, James Alfred,[1]	Worcester,	3 Nutting Avenue.
Little, Louis,	Leominster,	- -
Livermore, William Tingley,	Lawrence,	77 Pleasant Street.
Loring, Albert,	Hull,	53 Lincoln Avenue.
Lydiard, Harry Crowther,	Hartford, Conn.,	3 Nutting Avenue.
Mack, Walter Adams,	Springfield,	15 Phillips Street.
MacLeod, Daniel Johnson,[1]	Wakefield,	Brooks Farm.
MacNaught, Warren Henry,	Plymouth,	Corner of Hallock and North Prospect streets.
Mars, Malcolm Rowe,	Walpole,	56 Pleasant Street.
Martel, John Edward,	Turners Falls,	29 McClellan Street.
Mather, Fred,	Taunton,	Brooks Farm.
Maurer, Erwin Emil,	Yonkers, N. Y.,	12 Cottage Street.
Mayo, Frank Willard,	Houlton, Me.,	120 Pleasant Street.
Mayo, William Irving, Jr.,	Framingham Center,	M. A. C. Farm House.
McGuire, Raymond Thomas,[1]	Worcester,	17 Fearing Street.
McRae, Herbert Rankin,	Malden,	13 Fearing Street.
Merrill, Dana Otis,[1]	Pepperell,	6 Phillips Street.
Moorhouse, Newell,	Worcester,	17 Fearing Street.
Nash, Herman Beaman,	North Hadley,	Amherst.
Nason, Leonard Hastings,[1]	Auburndale,	Brooks Farm.
Nath, Morris,[1]	Dorchester,	41 Pleasant Street.

[1] Work incomplete.

Nelson, John Brockway,[1]	Newburyport,	Brooks Farm.
Nestle, William John,	Amherst,	32 Whitney Street.
Nims, Homer Willis,[1]	Montague,	21 Fearing Street.
Noyes, John Walker,[1]	Chelsea,	35 North Prospect Street.
Oertel, August Leonard,	South Hadley Falls,	Amherst.
Oliver, George Taylor, Jr.,[1]	Everett,	84 Pleasant Street.
Pareis, Egbert Leigh,	Elizabeth, N. J.,	66 Pleasant Street.
Patton, Willard Ginn,[1]	South Framingham,	M. A. C. Farm House.
Petit, Arthur Victor,[1]	Amherst,	31 East Pleasant Street.
Picard, Louis Francis,[1]	Hadley,	Hadley.
Pickard, Walter Douglas,	Hopedale,	77 Pleasant Street.
Pierce, Harold Barnard,	Kansas City, Mo.,	Corner Fearing and Pleasant streets.
Pike, Chester Arthur,[1]	Smith's,	24 Beston Street.
Poland, Robert Rantoul,[1]	West Acton,	24 Beston Street.
Porter, Wayland Robinson,	Amherst,	Amherst.
Pratt, Harold Arthur,	Shrewsbury,	Care of Professor Morton.
Purtle, William Edward,[1]	Monticello, Ky.,	6 Allen Street.
Pyne, Roger Sorenson,[1]	Springfield,	15 Phillips Street.
Quimby, Charles Frederick,	Cape Neddick, Me.,	35 East Pleasant Street.
Randall, Earle MacNeill,	Somerville,	44 Pleasant Street.
Ratner, Charles Cosrael,[1]	Springfield,	58 Pleasant Street.
Ritter, Ernest,	New Britain, Conn.,	120 Pleasant Street.
Rodger, Raymond Miller,	Everett,	9 Fearing Street.
Rorstrom, Hans Alfred,[1]	Boston,	Brooks Farm.
Rosequist, Birger Reignold,[1]	Brockton,	18 Nutting Avenue.
Ross, Louis Warren,	Arlington,	79 Pleasant Street.
Ruppell, Arthur Daniel,[1]	Lynn,	Care of E. F. Gaskill.
Rutter, Walter Frederick,[1]	Lawrence,	15 Fearing Street.
Saidel, Harry Samuel,	Worcester,	3 Nutting Avenue.
Sargent, George Leonard,	Merrimac,	46 McClellan Street.
Saville, William, Jr.,	Waban,	40 Amity Street.
Schaefer, Leonard Charles,[1]	Somerville,	36 North Prospect Street.
Schur, Arthur Leon,	Boston,	7 Nutting Avenue.
Schwab, Andrew Nathan,[1]	Yalesville, Conn.,	81 Pleasant Street.
Scott, George Alvin,[1]	Clinton,	36 North Prospect Street.
Seavey, Marden Homer,[1]	Westford,	Brooks Farm.
Sevrens, Linton Garfield,[1]	Medway,	– –
Shumway, Paul Edward,[1]	Greenfield,	60 Pleasant Street.
Simons, Clifton Harbough,[1]	Newton Center,	3 McClellan Street.
Sims, James Stanley,	Melrose,	13 Phillips Street.
Smith, Herbert Dwight,[1]	Poughkeepsie, N. Y.,	Care of S. J. Wright.
Smith, Hayden Henkel,	Springfield,	15 Phillips Street.
Smith, Richard Woodworth,	Pittsfield,	84 Pleasant Street.
Spaulding, Almon Whitney,	Dorchester,	18 Nutting Avenue.
Squires, Paul Revere,[1]	Belchertown,	Belchertown.
Stackpole, Frank Charles,[1]	Somerville,	18 Nutting Avenue.
Stearns, Carlton McIntyre,[1]	Melrose,	13 Phillips Street.
Stempler, Morris,[1]	Boston,	41 East Pleasant Street.
Stiles, Albert Ralph,	Arlington Heights,	36 North Prospect Street.
Stjernlof, Axel Uno,	Worcester,	Brooks Farm.
Stowell, Harold Thurber,[1]	Amherst,	193 South Pleasant Street.
Strong, William Andrew,	New York, N. Y.,	10 South College.
Sturtevant, Warren Butterfield,	Springfield,	83 North Pleasant Street.
Swett, Francis Stuart,	Southbridge,	116 Pleasant Street.
Swift, Raymond Walker,	North Amherst,	North Amherst.
Terrill, Herbert William,	Ansonia, Conn.,	North Pleasant Street.
Tucker, Arthur Currie, Jr.,[1]	Nyack, N. Y.,	81 Pleasant Street.
Tucker, Lee Heston,	Ware,	120 Pleasant Street.
Turner, Willis,	North Reading,	35 North Prospect Street.
Tuthill, Samuel Fuller,	Mattapoisett,	31 East Pleasant Street.
Upson, Everett Langdon,[1]	New Britain, Conn.,	Care of Professor Sears.

[1] Work incomplete.

Walbridge, Henry Blood,	Bennington, Vt.,	32 North Prospect Street.
Warner, Merrill Pomeroy,	Sunderland,	5 Nutting Avenue.
Warren, Harold Manson,	Melrose,	5 McClellan Street.
Warren, James Joseph,	North Brookfield,	35 North Prospect Street.
Westman, Robert Clayton,[1]	Roslindale,	Brooks Farm.
Wheeler, Chester Warren,	Southborough,	88 Pleasant Street.
Whitcomb, Warren Draper,[1]	Waltham,	120 Pleasant Street.
White, J. Edward Walbridge,[1]	North Bennington, Vt.,	32 North Prospect Street.
Whitney, Joseph Fradley,	Brooklyn, N. Y.,	52 Lincoln Avenue.
Wilber, Charles Raymond,	Walpole,	56 Pleasant Street.
Williams, Arthur Franklin,	Sunderland,	5 Nutting Avenue.
Williams, Herbert Clifton,	South Hadley Falls,	Care of Dr. Clark.

Unclassified Students.

Burckes, Harold James,	Waltham,	15 Phillips Street.
Comeau, Mark Walter,	Maynard,	75 Pleasant Street.
Dodd, Dexter Tiffany,	Chestnut Hill,	83 Pleasant Street.
Fellows, Katharine Adelheid,	Northampton,	38 Paradise Road, Northampton.
Fiske, Howard Benjamin,	Passaic, N. J.,	Care of C. W. Marshall.
Hamlin, Margaret Ruth Pomeroy,	Easthampton,	3 Fearing Street.
Healy, James John,	Florence,	35 North Prospect Street.
Hunnewell, Paul Fiske,	West Somerville,	13 Phillips Street.
Kelsey, Edmund Dean,	Cambridge,	79 Pleasant Street.
Kerr, Tracy,	Springfield,	Brooks Farm.
Lindsley, Horace Nelson,	Orange, N. J.,	83 Pleasant Street.
MooradKanian, Gregory,	Lawrence,	Hillside Avenue.
Morton, Leander Paul,	Amherst,	Care of Professor Morton.
Newton, Raymond Lovejoy,	Malden,	3 Nutting Avenue.
Putney, Roy Luther,	East Lynn,	Care of E. F. Gaskill.
Rossell, Irving Rowland,	Rahway, N. J.,	29 McClellan Street.
Stranahan, Mrs. Grace E.,	Montclair, N. J.,	Northampton.
Studley, Robert Allan,	Newton Highlands, Rockland.	44 Triangle Street.
Swofford, Lindsey,	Mt. Mitchell, N. C.,	– –
Talbot, Marjorie,	Roxbury,	Draper Hall.
Upham, Harland Willis,	Thornton's Ferry, N. H.,	8 Allen Street.
Watson, LeRoy Prouty,	Spencer,	66 Pleasant Street.
Willard, Harold Nelson,	Baltimore, Md.,	Care of Mr. Julian.
Winter, Henry George,	Ashburnham,	Care of E. F. Gaskill.

Summary by Classes.

Graduate students,	40
Senior class,	98
Junior class,	103
Sophomore class,	140
Freshman class,	202
Unclassified students,	24
Total registration,	607

Geographical Summary.

Massachusetts,	499
New York,	28
Connecticut,	24
New Jersey,	11
Vermont,	7
New Hampshire,	6
Pennsylvania,	6

[1] Work incomplete.

Rhode Island,	3
Ohio,	3
Maine,	3
Wisconsin,	2
Alabama,	1
Barbados,	1
Canada,	1
Colombia, S. A.,	1
Illinois,	1
Japan,	1
Kentucky,	1
Maryland,	1
Michigan,	1
Missouri,	1
Nebraska,	1
North Carolina,	1
Porto Rico,	1
Turkey,	1
Virginia,	1
Total,	607

Short Courses — 1913.

Winter School — 1913.

Abbot, Francis A.,	Harvard.
Abbot, Mary Perkins,	Harvard.
Allen, John S.,	Roxbury Crossing, 24 Edge Hill Street.
Angier, Henry,	Amherst.
Babbitt, Howard S.,	Chicopee, 340 Grove Street.
Bacon, Ralph D.,	Worcester, 401 Chandler Street.
Barker, Bowen,	Groton.
Barnes, Joseph C.,	Lanesborough.
Bartlett, C. S.,	Lowell, Hood Farm.
Barton, Charles E.,	Wilmington.
Bartow, Lathrop,	New York City, 33 West 73d Street.
Beals, Harry W.,	Plainfield.
Bean, Arthur H.,	Florence, 173 Spring Street.
Bickford, A. O.,	Hubbardston.
Bittinger, Fritz John,	Plymouth.
Borden, Aubrey W.,[1]	South Framingham.
Bridgman, Federal B.,	Northampton.
Bridgman, Gertrude L.,[1]	South Amherst.
Budd, Roger,	Holyoke, 7 Nonotuck Street.
Butterfield, L.,	Lexington.
Cady, C. M.,	Amherst.
Candage, Uzial F.,	Norfolk, Avery Street.
Cannon, T. Vincent,[1]	– –
Carleton, Boyd,	Boston, 170 Summer Street.
Cathie, Harold Gordon,	Needham, Pleasant Street.
Chambers, Maude B.,	Amherst, 8 Allen Street.
Chase, Newell D.,	Walbrook, Md.
Clapp, Roger W.,	Westhampton.
Clark, Leonard T.,	Wethersfield, Conn.
Coffin, Robert L.,	Amherst.
Cotter, William F.,	Salem, 25 Aborn Street.
Creesuy, Richard Lincoln,	Brookline, 48 Harris Street.
Crosby, Stanley W.,	Warren.
Darling, Ada Braun,	Greenfield.
Davis, Patrick,	Chestnut Hill, 40 Orchard Road.
Davis, Walter H.,	Amherst, R. F. D.
Day, Albert L.,	Graniteville.
Day, Don L.,	Cyrus.
Day, D. Percy,	West Kennebunk, Me.
Day, George Clarence,[1]	West Kennebunk, Me.
Dayton, Fred A.,	Springfield, 207 Bay Street.
Delano, Kenneth H.,	Boston.
Dickinson, Richard L.,	Sunderland.
Dole, Fred B.,	Shelburne.
Doran, Ralph C.,[1]	North Dartmouth.
Drake, Gilbert H.,	North Bellingham.
Dunbar, Guy C.,	Chestnut Hill, South Street.
Estabrook, O. B.,	Hopedale.
Evans, John M.,	Northampton, 21 Summer Street.
Fenn, Fred S.,[1]	Westminster, Vt.
Fiebiger, P.,	Granby.

[1] Withdrawn. Fee refunded on account of scarlet-fever epidemic.

Fisher, Mrs. Ellen N.,	Boston, 1359 Commonwealth Avenue.
Flint, Orville J.,	Westhampton.
Foley, Fred F.,	Fitchburg.
Francis, Benjamin A.,	Rock.
Fuller, Leroy D.,	Granby.
Goodrich, Mary E.,	Needham.
Greenwood, Laurence J.,	Billerica, Dudley Street.
Guild, Sydney T.,	Medford, 31 College Avenue.
Gummow, Earl R.,	Halifax.
Hannigan, William E.,	West Fitchburg, 171 Depot Street.
Harris, Myron A.,	Farmington.
Hepburn, Philip S.,	Sunderland.
Higgins, Edward L.,	North Billerica.
Hobart, Clarence A.,[1]	North Amherst.
Howells, Daniel W.,	179 Summit Avenue, Upper Montclair, N. J.
Ingalls, O. D.,	99 South Fullerton Street, Montclair, N. J.
Jackson, Charles A.,	Unadilla, N. Y.
Jenks, E. Lawrence,	Kensington, Conn.
Keefe, Mrs. Daniel F.,	Ipswich.
Keyes, F. Grant,	Bryantville.
Kilbourn, Walter G.,[1]	South Lancaster.
Kohl, Philip William,	Franklin, Lincoln Street.
Kress, Paul E.,	Hingham Center, Box 33.
Leavitt, Arthur W.,	Roslindale.
Lent, Paul H.,	Worcester.
Lerner, Rose S.,	Millis.
Lincoln, Jerome W.,	Taunton.
Lyman, C. E.,[1]	South Hadley.
Lyman, Frederick C.,	Amherst.
McGarry, Virginia,	Grafton, South Street.
McIntosh, Allan,	Needham, Great Plain Avenue.
Mason, Carrie L.,	Winchester, 31 Vine Street.
Meurisse, John,	Monson, R. F. D. No. 2.
Miller, Arthur L.,	Westborough.
Millett, Leon E.,	Whitman, Station A.
Moller, Martin T.,	Bridgeport, Conn.
Moore, A. S.,	Northampton.
Morton, Leander P.,	Amherst.
Moynahan, Felix,	Chicopee.
Murtaugh, Joseph P.,	Auburndale.
Nixon, William J.,	Roxbury, 36 Woodcliff Street.
Noonan, D. A.,	South Boston.
Nyce, Jonas W.,[1]	Sonderton, Pa., 114 Chestnut Street.
O'Rourke, John,	New Bedford.
Otis, W. H.,	Fitchburg.
Paley, Israel,	Colchester, Conn.
Paulson, Joseph W.,	Milton.
Pease, Harold M.,	Chester, R. F. D., No. 2.
Perley, Raymond,	Georgetown.
Perry, Roger Newton,	Worcester, 82 Park Avenue.
Pierce, Fred W.,	Wrentham, East Street.
Poor, Ben Perley,	North Andover, 341 Sutton Street.
Porter, William D.,	Holliston, R. F. D., No. 10.
Pratt, Anson M.,	Pownal, Vt.
Priest, Harold A.,	Gleasondale.
Prout, Norman W.,	Grafton.
Quinn, Joseph A.,	Amherst.
Rich, Alton F.,	Winthrop.
Robinson, H. V.,	Medford, 69 Summer Street.
Robsham, Rolf V.,	Northampton, 490 Elm Street.

[1] Withdrawn. Fee refunded on account of scarlet-fever epidemic.

Roe, Harold B.,	East Windsor, Conn.
Rothwell, Mrs. Bernard J.,	Needham.
Ross, Evan A.,	Northampton, 490 Elm Street.
St. Amand, Joseph F.,	Salem.
Scholz, Paul A.,	Adams.
Schwarz, Miss Julia,	Sharon.
Shannon, Arthur L.,	Millis, Exchange Street.
Sharkey, John E.,	Sunderland.
Sherwood, Grover,	Chester, R. F. D. No. 2.
Shipman, Raymond D.,[1]	South Hadley, R. F. D.
Simes, Louis,	Boston, 5 Tileston Street.
Smith, Harold,	Avon, Box 202.
Smith, Harry,	Revere, 99 Bellingham Avenue.
Smith, Linn A.,	Unadilla, N. Y.
Smith, L. Edmund,	West Brookfield.
Spencer, J. Arthur,	Milton.
Steacie, Edward, Jr.,	Dorchester, 37 Bloomfield Street.
Talmage, Frank M.,	Great Barrington.
Taylor, Frank R.,	Frye, Me.
Taylor, Dr. Frederick Leon,	Natick, Forest Avenue.
Thompson, Charles Bush,	Dover.
Thompson, Ralph M.,	Winchester.
Tomlinson, Bertram,	Northampton, 25 James Avenue.
Tracy, Alfred E.,[1]	South Boston, 504 Sixth Street.
Truesdell, Clarence E.,	Zoar.
Turner, Ralph C.,	Upham's Corner, 54 Grampian Way.
Twombly, Harry,	New London, N. H.
Vincent, T. Lawrence,	Torrington, Conn., R. F. D.
Waid, B. F.,	Amherst, 61 Amity Street.
Warner, J. H.,	Sunderland.
Wetherbee, Dwight E.,	Amherst.
White, Alfred Baylies,	Taunton, 120 High Street.
Whiting, Charles Theodore,	Greenfield.
Whitlock, Aaron A.,	Warehouse Point, Conn.
Whittaker, Clifford F.,	Taunton.
Wilbur, Woodward Arthur,	Lanesborough, Lincoln Street.
Wildes, Theo. B.,	Boston, 31 Marlborough Street.
Williams, Alexander,	Boston, Hotel Charlesgate.
Willett, George B.,	Dracut.
Wolschendorf, George E.,	Whitman.
Woodman, Rodney Canfield,	Milford, 12 Amherst Street.
Young, Harold B.,	Yalesville, Conn.
Zappey, J. Frederick,	West Wrentham.

Students in Apple-packing School, Jan. 23–29, 1913.

Barker, Bowen,	Groton.
Brooks, George A.,	Boston, 18 Derne Street.
Bruner, Myron L.,	Wilbraham.
Byrne, Edward J.,	Ardmore.
Capen, Samuel H.,	Dedham.
Davis, W. M.,	Boston, 93 Beach Street.
Emerson, W. K.,	Concord Junction.
Foster, H. K.,	Ashby.
Guild, S. T.,	Medford, 31 College Avenue.
Hall, Russell B.,	Amherst.
Jenks, L. P.,	Williamstown.
Laboutely, G. E.,	Belchertown.
Lerner, Rose,	Peru.
Mason, O. N.,	Wrentham.
Moran, T. H.,	Jericho, Vt.
Nyce, Jonas W.,	Sonderton, Pa., 114 Chestnut Street.

[1] Withdrawn. Fee refunded on account of scarlet-fever epidemic.

Parsons, Wilfred A.,	Southampton,
Paul, Eleanor Frances,	Sherborn.
Reid, John,	Woronoco.
Sampson, S. D.,	M. A. C., 1913.
Searle, Edward C.,	Southampton,
Snyder, Henry H.,	Cummington.
Watson, Ralph C.,	South Freeport, Me.
Wood, Burt F.,	Athol.
Wooding, E. M.,	Clintonville, Conn.

School for Tree Wardens, 1913.

Abbe, F. H.,	Boston.
Bailey, L. S.,	Middleborough.
Bailey, Mrs. L. S.,	Middleborough.
Ball, L. P.,	Winchendon.
Bean, Minot A.,	Chelmsford.
Bemis, E. L.,	Brookfield.
Bragg, J. W.,	Greenfield.
Bray, Thomas A.,	Holyoke, 19 Laurel Street.
Breed, Edward W.,	Clinton.
Brown, Percival S.,	Scituate.
Burns, Wm. G.,	Greenfield.
Callahan, James F.,	Peabody.
Campbell, Wm. A.,	Greenfield.
Carrick, Thomas F.,	Dracut, R. F. D.
Cutter, H. A.,	Bedford.
Davis, J. Alden,	Springfield.
Dodge, A. W., Jr.,	Reading.
Eastman, Geo. F.,	Granby.
Field, A. F.,	Hillsborough.
Gay, E. F.,	Norwood.
Gaylord, R. S.,	Hadley.
Guptill, Melvin,	Boston, 49 North Washington Street.
Haskell, T. P.,	Northborough.
McLaughlin, J. H.,	Millers Falls.
Mills, D. C.,	Fitchburg.
Moore, C. A.,	Westfield.
Neale, Harold J.,	Worcester.
O'Brien, Wm. H.,	North Billerica.
Pierpont, John E.,	Williamsburg.
Peeso, J. A.,	Belchertown.
Phillips, Albert A.,	Greenfield.
Rane, F. W.,	Boston.
Reynolds, Harriet,	Boston, 4 Joy Street.
Ruch, C. N.,	Granby.
Sautelle, B. A.,	Greenwich.
Shaw, Frank H.,	Rockland.
Southard, F. D.,	Milton.
Symmes, Samuel S.,	Winchester.
Wilkins, Geo. S.,	Carlisle.
Whitaker, C. L.,	New York City, 470 4th Avenue.
Whitney, Geo. A.,	Athol.
Woothly, L. H.,	Boston.
Zeissig, S. E.,	Ware.

Bee Course, 1913.

Baker, H. Raymond,	Amherst.
Dickens, Gustav,	Cheshire, Conn.
Haynes, Edgar G.,	Suffield, Conn.
Lord, Carey Stevens,	Richmond.
Loverin, Harriet,	Shelton, Conn.
Robinson, Lucy M.,	Waltham.

STUDENTS OF THE SUMMER SCHOOL, 1913.

Adams, Mabelle,	97 Paradise Road,	Swampscott.
Alden, Marie P.,	365 Hancock Street,	Brooklyn, N. Y.
Allen, H. C.,	–	Phoenix, Ariz.
Anderson, Sheed,	497 Warren Street,	Roxbury.
Bachelder, Grace,	9 St. James Avenue,	Boston.
Banning, Laura,	242 South 4th Avenue,	Mt. Vernon, N. Y.
Bantle, Ida E.,	–	Amherst.
Barker, Luliona,	–	Amherst.
Batchelder, Isabel,	Hillside Street,	Amesbury.
Bill, Mrs. Mary E.,	58 Prospect Street,	Waltham.
Blackmer, Nellie E.,	106 Euclid Avenue,	Springfield.
Bousfield, Mary,	1 Whiteley Street,	North Adams.
Briggs, Rose,	R. F. D.,	Bournedale.
Britton, Harriet W.,	47 Farmington Avenue,	Hartford, Conn.
Brockway, Clarence A.,	31 Hancock Street,	West Springfield.
Brooks, Laura J.,	31 Stevens Street,	Stoneham.
Brooks, Loura L.,	62 Chestnut Street,	Gardner.
Brown, H. Whittemore,	Elm Street,	Concord.
Brown, Marion S.,	946 Central Avenue,	Plainfield, N. J.
Brown, Percy M.,	946 Central Avenue,	Plainfield, N. J.
Brown, Susie,	–	Amherst.
Brownell, Harriet M.,	–	Bryn Mawr, Pa.
Bryant, Bertha W.,	Rest Hill,	Woburn.
Burnap, Margaret,	Rest Hill,	Woburn.
Capen, Arthur C.,	–	Worthington.
Chamberlin, Mrs. Edwin,	2 Avon Street,	Cambridge.
Chamberlin, Edwin,	2 Avon Street,	Cambridge.
Clapp, Harriet A.,	9 Rockledge Place,	Yonkers, N. Y.
Clark, Mrs. R. F.,	42 West 35th Street,	New York, N. Y.
Clark, Ruth,	10 Hallock Street,	Amherst.
Clark, Katherine,	–	North Amherst.
Cornell, Edward B.,	–	Haverhill, N. H.
Crew, Caroline L.,	903 Tatnall Street,	Wilmington, Del.
Darrow, W. H.,	16 Bennock Street,	Orono, Me.
Davis, Irving L.,	–	Brimfield.
Davis, Emma A.,	60 High Street,	Medford.
Dean, Lucy,	416 Marlborough Street,	Boston.
Douglas, Nan,	South Main Street,	Great Barrington.
Dowe, Amy H.,	50 Summer Street,	Norwich, Conn.
Drake, Mary A.,	53 Institute Road,	Worcester.
Eastman, Dora W.,	United States Indian School,	Genoa, Neb.
Eastwood, Wm.,	507 Beacon Street,	Boston.
Emerson, Marguerite,	395 Broadway,	Cambridge.
Felton, F. Ethel,	9 Phillips Street,	Amherst.
Fimiss, Mrs. M. A.,	57 High Street,	Medford.
Flagg, Sadie E.,	–	West Berlin.
Frost, Mildred N.,	106 Pleasant Street,	Newton Center.
Glazier, Leta M.,	–	Amherst.
Goodnow, Edna M.,	–	Amherst.
Hall, Florence J.,	–	Waltham.
Hall, Ida E.,	–	Waltham.
Harris, Jessie F.,	9 Silver Street,	Worcester.
Hunck, Walter L.,	3114 West 8th Street,	Cincinnati, O.
Hunck, Roland M.,	3114 West 8th Street,	Cincinnati, O.
Hayward, Marguerite,	8 Dana Street,	Cambridge.
Hewins, Alfred S.,	Maple Place,	Dedham.
Holden, Clara B.,	19 Avon Street,	Melrose.
Hooker, Bessie M.,	5 North East Street,	Amherst.
Howard, Clara,	–	North Amherst.
Howe, Florence I.,	28 Myrtle Street,	Leominster.
Howlett, Cora M.,	–	South Amherst.

Hoyt, Laura A.,	68 Federal Street,	Greenfield.
Hurlin, Edna M.,	77 Mayfield Street,	Boston.
James, J. E.,	446 Marlborough Street,	Boston.
Janvier, Margaret R.,	– –	Lansdowne, Pa.
Johnson, Roscoe E.,	14 Roberts Hall,	Waterville, Me.
Kellogg, Ella,	– –	North Amherst.
Kennedy, Anna,	30 Park Avenue,	South Weymouth.
Kezar, Myrtle E.,	– –	Belchertown.
Knowles, Grace,	1 Roxbury Avenue,	Natick.
Lane, Madeline H.,	– –	Great Barrington.
Lawrence, N. Louise,	425 Marlborough Street,	Boston.
McBurney, Henry,	35 Lincoln Avenue,	Amherst.
MacDonald, Ruby,	456 Centre Street,	Jamaica Plain.
Marble, Mrs. W. Cary,	1970 Morgan Avenue,	Hollywood, Cal.
Marsh, Ida M.,	The Capitol,	Albany, N. Y.
Maynard, Pearl A.,	447 Crafts Street,	West Newton.
Mead, S. Gordon,	Lake Waranaug,	New Preston, Conn.
Milligan, Lester O.,	Box 186,	Dalton.
Mills, Mabelle L.,	– –	Amherst.
Nestle, Grace,	– –	Amherst.
O'Hern, Elizabeth V.,	85 Furnace Street,	North Adams.
Parsons, Elsie J.,	11 School Street,	Adams.
Pease, Willard,	Pleasant Street,	Amherst.
Perry, Gerald,	17 Amity Street,	Amherst.
Pettis, Sybil,	– –	Thompson, Conn.
Phillips, Arthur W.,	10 Prospect Hill,	Somerville.
Phillips, Ralph O.,	10 Prospect Hill,	Somerville.
Platt, Mrs. Royal T.,	Laconic Avenue,	Great Barrington.
Porter, Grace,	Perkins Institute,	Watertown.
Pulsifer, Woodbury,	– –	Washington, D. C.
Putnam, Charles S.,	Care of A. E. Sargent, R.F.D.	Groton.
Raker, Helen S.,	39 Magazine Street,	Cambridge.
Reidy, Lillian C.,	169 East 90th Street,	New York, N. Y.
Richards, Clinton J.,	22 Prospect Avenue,	Northampton.
Robinson, Dr. Mary B.,	30 Harris Street,	Waltham.
Rowell, Alice M.,	– –	Tilton, N. H.
Sanborn, Arthur,	183 Central Street,	Winter Hill.
Scheuele, J. A.,	Hampt. County Imp.,	Springfield.
Seaver, Myrtle B.,	– –	Williamstown.
Severance, Caroline,	– –	Amherst.
Shumway, Ruth,	– –	Amherst.
Small, Lucy B.,	– –	North Truro.
Smith, Abbie M.,	– –	Salisbury.
Spaulding, Lyford P.,	23 Waltham Street,	Lexington.
Spear, Harriet,	– –	North Amherst.
Stebbins, Dorothea,	405 Marlborough Street,	Boston.
Steinhauer, E. K.,	– –	Rome, N. Y.
Stewart, Isabel A.,	161 West 14th Street,	New York City.
Thorpe, Willis E.,	8 Ash Street,	Danvers.
Thurston, Grace R.,	111 Gainsboro Street,	Boston.
Thyng, Mary E.,	19 Cherry Street,	Lynn.
Upham, Harlan W.,	– –	Thornton's Ferry, N. H.
Vietz, Paul W.,	– –	West Acton.
Walker, Geo. J.,	– –	Lexington.
Webb, D. Frances,	9 Phillips Street,	Amherst.
Weeks, Gertrude,	25 Peterborough Street,	Boston.
Welch, Anna G.,	32 Fenwick Street,	Somerville.
Whitcomb, Ralph,	– –	Amherst.
White, Jr., Robert,	1039 Massachusetts Avenue,	Cambridge.
Wight, Mrs. Charles L.,	– –	Honolulu, Hawaii.
Winslow, Alice V.,	Normal Hall,	Framingham.
Winslow, Isabelle F.,	257 Steuben Street,	Brooklyn, N. Y.
York, Mrs. Olla A.,	2 Fearing Street,	Amherst.

Greene, Mrs. Anna A., . . .	–	Cotuit.
Morton, Charlotte, ...	–	Amherst.
Nickerson, Mrs. C. E., . . .	–	Amherst.

School for Rural Social Workers, 1913.

Guptill, Roger S., ...	–	Kingston, N. H.
Jobbins, Rev. E. W., . . .	Granby Road, . . .	Southwick.
Kebbe, David L., ...	–	Cummington.
Klinck, L. S., ...	MacDonald College, . .	Quebec, Can.
Panunzio, C. M., ...	Box 547, ...	Amherst.
Patt, Hermann G., ...	–	Granville.

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Public Document No. 31

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OF THE

MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION.

PARTS I. AND II.,

BEING PARTS III. AND IV. OF THE FIFTY-FIRST ANNUAL REPORT OF THE MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1914.

ENDING THE THIRTY-FIRST YEAR FROM THE FOUNDING OF THE STATE AGRICULTURAL EXPERIMENT STATION.

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TWENTY-SIXTH ANNUAL REPORT

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PART I.

REPORT OF THE DIRECTOR AND OTHER OFFICERS.

PART II.

DETAILED REPORT OF THE EXPERIMENT STATION.

A RECORD OF THE THIRTY-FIRST YEAR FROM THE FOUNDING OF THE STATE AGRICULTURAL EXPERIMENT STATION.

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PART I.

Part II.

Massachusetts Agricultural Experiment Station.

OFFICERS AND STAFF.

COMMITTEE.

STATION STAFF.

Administration.

WILLIAM P. BROOKS, Ph.D., *Director*.
JOSEPH B. LINDSEY, Ph.D., *Vice-Director*.
FRED C. KENNEY, *Treasurer*.
CHARLES R. GREEN, B.Agr., *Librarian*.
Mrs. LUCIA G. CHURCH, *Clerk*.
Miss GRACE E. GALLOND, *Stenographer*.

Agriculture.

WILLIAM P. BROOKS, Ph.D., *Agriculturist*.
HENRY J. FRANKLIN, Ph.D., *In Charge Cranberry Substation*.
EDWIN F. GASKILL, B.Sc., *Assistant Agriculturist*.

Chemistry.

JOSEPH B. LINDSEY, Ph.D., *Chemist*.
EDWARD B. HOLLAND, M.Sc., *Associate Chemist in Charge (Research Section)*.
FRED W. MORSE, M.Sc., *Research Chemist*.
HENRI D. HASKINS, B.Sc., *Chemist in Charge (Fertilizer Section)*.
PHILIP H. SMITH, M.Sc., *Chemist in Charge (Food and Dairy Section)*.
LEWELL S. WALKER, B.Sc., *Assistant Chemist*.
RUDOLF W. RUPRECHT, B.Sc., *Assistant Chemist*.
CARLTON P. JONES, M.Sc., *Assistant Chemist*.
CARLOS S. BEALS, B.Sc., *Assistant Chemist*.
WALTER S. FROST, B.Sc., *Assistant Chemist*.
JAMES P. BUCKLEY, Jr., *Assistant Chemist*.
JAMES T. HOWARD, *Inspector*.
HARRY L. ALLEN, *Assistant in Laboratory*.
JAMES R. ALCOCK, *Assistant in Animal Nutrition*.
Miss F. ETHEL FELTON, A.B., *Clerk*.
Miss ALICE M. HOWARD, *Clerk*.
Miss REBECCA L. MELLOR, *Clerk*.

Entomology.	Henry T. Fernald, Ph.D., *Entomologist.* Burton N. Gates, Ph.D., *Apiarist.* Arthur I. Bourne, A.B., *Assistant Entomologist.* Miss Bridie E. O'Donnell, *Clerk.*
Horticulture.	Frank A. Waugh, M.Sc., *Horticulturist.* Fred C. Sears, M.Sc., *Pomologist.* Jacob K. Shaw, Ph.D., *Research Pomologist.* John B. Norton, B.Sc., *Graduate Assistant.*
Meteorology.	John E. Ostrander, A.M., C.E., *Meteorologist.* E. K. Dexter, *Observer.*
Poultry Husbandry.	John C. Graham, B.Sc., *Poultry Husbandman.* Hubert D. Goodale, Ph.D., *Research Biologist.* Miss Fay L. Milton, *Clerk.*
Vegetable Pathology and Physiology.	George E. Stone, Ph.D., *Vegetable Physiologist and Pathologist.* George H. Chapman, M.Sc., *Research Vegetable Physiologist.* Orton L. Clark, B.Sc., *Assistant Vegetable Physiologist and Pathologist.* Miss Jessie V. Crocker, *Clerk.*
Veterinary Science.	James B. Paige, B.Sc., D.V.S., *Veterinarian.*

REPORT OF THE DIRECTOR.

WM. P. BROOKS.

ADMINISTRATION.

Station Staff.

From Oct. 1, 1912, to September, 1913, thus including the greater part of the director's leave of absence, the administrative duties of the office were faithfully and ably discharged by Mr. F. W. Morse, research chemist in agronomy, of our department of chemistry. It is a pleasure to testify not only to the fine tact and good judgment shown in a position necessarily somewhat difficult to fill, but as well to express appreciation of the effective initiative shown by Mr. Morse at a time particularly critical in the financial relations of the station to the State. The material increase in the annual provision made by the last Legislature for the support of the station, reported in detail under a topic considered later, is the best evidence of the quality of his work. It is a pleasure, also, to say that in all the phases of the work of the director's office the vice-director, Dr. J. B. Lindsey, took his accustomed hearty interest, gave most freely of his time, and contributed no little to its successful administration. The splendid *esprit de corps* shown by all the members of the staff should also be mentioned. Each fully met the responsibilities of his position, and more; and it is in a sense invidious to recognize especially the services of the first clerk of the administrative department, Mrs. L. G. Church, and the assistant agriculturist, Mr. E. F. Gaskill, to whom, however, inevitably fell an unusual share of the duties usually devolving upon the director and agriculturist.

On the resumption of my duties as director on September 1 Professor Morse was once more able to devote his entire time to the important lines of research connected with the nutrition of

asparagus and the cranberry, and the specific effects of certain fertilizer chemicals upon the soil, in which he has been engaged for the past few years.

The station has been fortunate in retaining the services of all the senior members of its staff. This has been strengthened and the scope of its work increased by the appointment on February 1 of H. D. Goodale, Ph.D., as research biologist in the poultry department. Other new appointments in the same department are Mr. J. W. Sayer, foreman, Mary R. Kingsbury and Fay L. Milton as clerks, the latter replacing Miss Kingsbury in September. An added assistant was rendered necessary by the increase in the amount of work connected with the inspection of commercial fertilizers, and W. S. Frost, B.Sc., of Tufts College, was appointed assistant chemist. John B. Norton, B.Sc., University of Vermont, was appointed to the vacancy as graduate assistant in horticulture in May. Miss Lina E. Fisher, who had given one-half her time to the clerical work of the department of chemistry, was transferred in October to the chemical department of the college, her place being taken by Miss Rebecca L. Mellor, who similarly gives one-half her time to the clerical work of the department of chemistry. Mr. James C. Reed, who for several years had served as assistant, a considerable portion of the time in the research section, resigned in June to accept a position as chemist in connection with the manufacture of commercial feeds. His place was filled by the appointment of Mr. J. P. Buckley, who had taken courses of study in the Massachusetts Institute of Technology.

Geo. H. Chapman, research vegetable physiologist and pathologist, was granted eight months leave of absence, beginning September 1. Mr. Chapman will spend most of his time in study abroad. Orton L. Clark, B.Sc., was at the same time employed in the department, and is engaged in important lines of research.

Maintenance.

At the beginning of the fiscal year, Dec. 1, 1912, the increase in the State appropriation for the support of the experiment station from $10,500, at which figure it had stood for many

years, to $15,000, as provided by the Legislature of that year, became effective. The Legislature of 1913 passed an act increasing the annual State appropriation for investigation $5,000 per year for five years, beginning Dec. 1, 1913.

Other sources of income to the station have remained practically unchanged, and the gradual increase in the amount received from the State provided by the act just referred to will hardly suffice to enable the station to increase the scope of its work with the constantly broadening horizon and to meet the rapidly increasing demands upon it for service.

The federal appropriations have remained unchanged for three years. The amounts received from products sold, for labor for other departments of the institution, for chemical work and cow testing are subject to variation from year to year and cannot be estimated with entire safety in making up the annual budget. It is true, however, that the aggregate usually reaches a considerable sum. The amounts received during the past year are shown in the general table. The receipts from the sale of cranberries produced at the substation in Wareham were exceptionally large, as the crop was the most abundant produced since it has been the property of the station.

Attention is called to the fact that the fees received for the inspection of commercial fertilizers and the State appropriation for the execution of the feed law are almost entirely required in meeting the expenses connected with our control work. The amended laws now upon the statute books, however, provide that unexpended balances may be used in case of the fertilizer control work for investigations in relation to the use of manures and fertilizers, and in the case of the feed law for investigations in relation to foodstuffs and the feeding of farm animals. The balances so expended during the past year have been: —

From the fertilizer inspection, ...	$516 16
From the feed law appropriation, ...	350 00

Total Revenue for the Fiscal Year Dec. 1, 1912, to Dec. 1, 1913.

State appropriation,	$15,000 00
Federal appropriations: —	
Hatch fund,	15,000 00
Adams fund,	15,000 00
Agricultural department sales and labor,	2,740 01
Chemical department analytical work, cow testing, etc.,	9,038 81
Fertilizer law, analysis fees,	10,580 00
Feed law, State appropriation,	6,000 00
Cranberry substation: —	
Sales of fruit,	5,671 82
Sales of vines,	19 65
Meteorological observations, scientific services, etc.,	193 03
Total,	$79,243 32

The total amount available for investigation is about $16,000 less than the above total, about that sum being required for the execution of the feed and fertilizer laws.

The treasurer's report in full will be found on pages 40*a* and 41*a*.

Publications.

The following is a complete list of the station publications for the fiscal year just ended: —

Annual Report.

Twenty-fifth Annual Report: Part I., 240 pages; Part II., 97 pages.

Separata from Annual Report.

Report of the Cranberry Substation, 28 pages.
Report of the Botanist, 104 pages.
Report of the Entomologist, 21 pages.
The Inheritance of Blossom Color in Beans, 24 pages.

Bulletins.

No. 143. Inspection of Commercial Fertilizers, by H. D. Haskins, L. S. Walker, C. P. Jones and C. L. Beals; 93 pages.

No. 144. The Relation of Light to Greenhouse Culture, by G. E. Stone; 40 pages.

No. 145. Record of the Station Dairy Herd and the Cost of Milk Production, by J. B. Lindsey; 31 pages.

No. 146. Inspection of Commercial Feedstuffs, by P. H. Smith and C. L. Beals; 61 pages.

Circulars.

No. 35. Poultry Manures, their Treatment and Use; revision of No. 22; 4 pages.

Meteorological Reports.

Twelve numbers, 4 pages each.

Publications Available for Distribution.

Bulletins.

No. 33. Glossary of Fodder Terms.
No. 115. Cranberry Insects.
No. 123. Fungicides, Insecticides and Spraying Directions.
No. 130. Meteorological Summary — Twenty Years.
No. 133. Green Crops for Summer Soiling.
No. 134. The Hay Crop.
No. 137. The Rational Use of Lime.
No. 139. Tomato Diseases.[1]
No. 144. The Relation of Light to Greenhouse Culture.
No. 145. The Cost of Milk Production.
No. 148. On the Diagnosis of Infection with Bacterium Pullorum in the Domestic Fowl.[2]
No. 149. A Study of Variation in Apples.
No. 150. Reports on Experimental Work in Connection with Cranberries.
No. 151. The Determination of Acetyl Number.
No. 152. The Digestibility of Cattle Foods.
No. 153. A Summary of Meteorological Records for Twenty-five Years.
No. 154. Alfalfa.
No. 155. New Fertilizer Materials and By-products; and Cocoanut Meal.
Nos. 131, 135, 140. Inspection of Commercial Fertilizers for the Years 1909, 1910 and 1911.
Nos. 132, 136, 139, 142. Inspection of Commercial Feedstuffs for the Years 1909, 1910, 1911 and 1912.

Annual Reports.

Hatch Experiment Station: Fifth (1893); Sixth (1894); Tenth (1898); Eleventh (1899); Twelfth (1900); Thirteenth (1901); Fourteenth (1902); Fifteenth (1903); Sixteenth (1904); Seventeenth (1905).

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[1] Edition nearly exhausted.
[2] Bulletins 148–155 were not printed until after the end of the year covered by this report; but are here included, as the date of printing the report is later than the dates of printing these bulletins.

Massachusetts Agricultural Experiment Station: Twentieth (1908); Twenty-first, Part II. (1909); Twenty-second, Part I. (1910); Twenty-third, Part I. (1911); Twenty-fourth, Parts I. and II. (1912); Twenty-fifth, Part I. (1913).

Circulars.

No. 20. Lime in Massachusetts Agriculture.
No. 27. Seeding Mowings.
No. 29. Soil Analysis.
No. 36. Poultry Manures, their Treatment and Use.
No. 37. Green Manuring and Cover Crops.
No. 38. Cabbage, Cauliflower, Turnip, Rape and Other Crucifers.
No. 40. Downy Mildew of Cucumbers.
No. 41. The Control of Onion Smut.
No. 42. Fertilizers for Potatoes.
No. 43. Cut Worms.
Home Mixed Fertilizers.
Orchard Experiment.
Fertilizers for Corn.
Composition and Digestibility of Fodder Articles; Composition of Fertilizer Materials, Refuse Substances, Garden Crops and Soils. (A separate from the twenty-third annual report.)
For distribution in Massachusetts, Bulletin No. 180 of the Connecticut Agricultural Experiment Station: Studies on the Tobacco Crop of Connecticut, by Director E. H. Jenkins.

The plan followed in the distribution of our publications during the past year has been the same as for several years, and is described in the twenty-fourth annual report. The demand, however, has greatly increased and the size of editions must be correspondingly increased. The edition of a number of the bulletins has recently been entirely exhausted within a few weeks after publication, while requests for them will continue for months and even years. With the increase in interest in scientific agriculture and country life, with the multiplication of institutions in which agriculture is taught, and of those, both public and private, devoted to agricultural experiment and demonstration, with the fuller development of agricultural extension service under the recently enacted Lever bill, and the organization of the county league or agent system, is sure to come a yet more rapid growth in demand for station publications.

Thus far it has been the policy in this station, as it is in most, to send publications on request to citizens of other States. This is sound policy from the standpoint of publication efficiency, and fully justified by the fact that a large share of the funds for the support of our experiment stations comes from the federal treasury. The fullest reciprocity is desirable, for in most cases results obtained in one State find almost equal application in numerous others.

Still another cause of increased demand is found in connection with schools which teach agriculture, which, in not a few cases, make use of bulletins in their class work, for which purpose a large number of duplicate copies is often requested. It has thus far been our policy to meet this demand also when possible.

If we are to continue in the future the generous policy of the past, and to meet the increasing demands which have been referred to, it will become necessary either to greatly increase the expenditure for publication or to curtail circulation in certain directions. It is believed that the latter course can be followed without disadvantage to any real interest. A careful study of the situation as affected by the existing law governing the publication of our annual reports has led to the conclusion that there is wasteful circulation and some duplication, resulting from the inclusion of the formal technical parts of our reports in the annual reports of the secretary of our State Board of Agriculture; and a plan which shall at the same time avoid such waste and duplication and bring our method of publication into conformity with the plan recommended by the American Association of Agricultural Colleges and Experiment Stations has been embodied in an amended act which will be brought before the Legislature of 1914. The act as amended leaves the determination of the size of the editions, within a specified maximum, to the director, who will be able to adapt any edition to the prospective demand, which varies widely for different publications. The advantages of the act as amended are so clear that its passage is confidently looked for.[1]

A list of such of our publications as can still be sent on request will be found on page 7*a*.

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[1] This act was passed before the date of printing.

Mailing Lists.

The fullest economy in the matter of the circulation of station publications is possible only when the mailing lists are kept fully alive. Very frequent revisions are necessary. It is true that the United States postal regulations state that postmasters must return all station publications not delivered, but in a very large proportion of cases this regulation is not complied with. It has been our practice, therefore, not only to make corrections whenever reported, and to drop names when publications are returned, but to fully revise all Massachusetts lists once in two years. Under these conditions the number of addresses which we find should be dropped because of death, removal or other causes is surprising. It must average about 20 to 25 per cent. of the total. There is also an astonishing number of changes shown to be necessary in every revision. These are due in many cases to removal, but in not a few instances to changes in post offices. It is estimated that in the last revision about one-half of the addresses remaining required change. There is much difference in the number for different post offices, a difference no doubt traceable to difference in the faithfulness with which the postal regulation above referred to is complied with. The table shows the nature of the lists which we at present maintain and the numbers in the several classes.

Residents of Massachusetts (general),	13,325
Residents of other States (general),	557
Residents of other States (general and technical),	765
Residents of foreign countries,	154
Newspapers,	513
Libraries,	343
Exchanges,	189
Cranberry growers,	1,710
Beekeepers,	3,719
Feed and fertilizer dealers,	310
Greenhouse growers,	1,848
Meteorological,	386
United States Department of Agriculture Official List,[1]	2,794
Total,	26,613

[1] Publications are not as a rule sent to all on this list but only to presidents, directors, libraries and specialists likely to be interested.

The general list, as will be seen, includes 13,325 names. It is felt that sending all publications except those of a highly technical character (which we always give a much more restricted circulation) to all the persons on the list doubtless involves considerable waste. Our agriculture is highly specialized in many sections. Our publications on specialized branches of agriculture are of interest only to those engaged in them, and it is our policy to increase the number of special lists with a view to a better and more economical, and at the same time more effective, circulation of our various publications.

Extension Service.

The experiment station is still called upon for a large amount of service which is really of the character of extension. The extension service of the college, under Prof. W. D. Hurd, is now handling an enormous number of requests for information and advice; but the appreciation of and call for such assistance has grown with such rapidity that there has been no appreciable decrease in the number of calls upon the specialists of the station staff. Correspondence still makes heavy demands upon their time. They still accept many invitations for public lectures and demonstrations all over the State. It is the policy in the institution that this work shall be done mainly by members of the extension service staff. The specialists of the experiment station must naturally always be in demand for addresses on certain subjects, but since it is recognized that meeting many engagements of this character interferes greatly with research efficiency, such addresses should be restricted within narrow limits.

Needs of the Station.

Attention has been called to the fact that the gradual increase in the amount appropriated by the State for the support of the experiment station is not adequate; but as the act of the Legislature making provision for such increase was made with a fairly definite understanding that further increase would not be asked for within the period covered by the act, it would be contrary to sound policy to ask an increase in appropriation

for general purposes. There are, however, two needs so pressing that they must be stated and should be provided for as soon as possible. These are additional land and an appropriation for demonstration on selected farms throughout the State.

Land. — The area available for experiment in the departments of agriculture and horticulture is far too small. There has been no increase for many years except by lease, a system which has numerous disadvantages which are referred to later. Meanwhile, the science of agriculture has gained rapidly. New discoveries constantly widen our horizon. Investigations are now needed in fields undreamed of not many years ago. Soil biology, soil physics, the influence of toxins, the theory of antagonism, are a few among the many fields in which work is urgently needed.

The station now leases four different areas for experiment, — two and one-half acres in Concord for work with asparagus, which has been held for seven years on an indefinite lease; six and one-half acres in South Amherst for orchard experiments, leased for ten years, seven of which have already passed; eighteen acres adjoining the station grounds in Amherst, leased for orchard experiments in 1912 for twenty years; and two acres, also in Amherst but not immediately adjoining the station grounds, which we have used for one year on a four-year lease.

In the case of the areas in Concord and South Amherst there has already been paid for the use of the land sums in each case considerably in excess of the figure at which these properties could have been purchased. The same will be true of one at least of the other areas mentioned within a very few years. The policy of leasing is not, therefore, a sound one from the standpoint of economy. There are, however, much more important objections, chief among which is the uncertainty of tenure for the full period during which the experiment should continue. This cannot be determined in advance. In the case of the South Amherst area it was thought when the lease was executed that the specific problem for which it was desired could be solved within the ten years, but it is already apparent that it would be a great advantage to continue the varying fertilizer and cultural treatments during a much longer period,

in order to determine more fully the ultimate effects upon the apple, which is a very long-lived tree. We already know that the present owner (who has purchased the property since we hired it) will not renew at any figure which the station can afford to pay. We shall find ourselves, therefore, three years hence, compelled to turn over to the owner a piece of property worth several times what it was when we leased it, having meanwhile paid the former owner and to the present one a total sum considerably in excess of the value when the land came under our management.

The situation as affecting the Concord land, planted to asparagus (also a long-lived crop), is from a business point of view entirely similar; but as the lease of this land is indeterminate it is yet worse from an experimental viewpoint, for the owner may terminate the lease at any time. Fortunately, such action on his part is not now anticipated, for he is very greatly interested in the experiment; but we are entirely dependent upon his good will.

Another point to be considered is that the value of areas suitable for our needs is steadily appreciating. Land can probably never be bought at lower prices than now. It would seem the part of wisdom to take early action.

Not only do sound business considerations urge this course, but the need becomes every year more desperate as the area which has been available for station use is more and more encroached upon as the result of the growth of the educational side of the institution. The location of buildings has already rendered far less valuable or entirely valueless for our use three fields in which important lines of inquiry were in progress, and other locations which will have a similar effect are in prospect.

Still another point has an important relation to our need. With the great increase in the number of students who room in all parts of the town, and with the erection of new buildings in different parts of the campus between which large numbers of students must pass in going to and from classes, it has become almost impossible to prevent trespass, as a student in a hurry is disposed to cut corners, which means crossing the plots. It seems to the director, and to all members of the station staff

familiar with the situation, and especially to those directly interested in the use of land, that a candid consideration of the facts stated, and of others which might be presented, leads inevitably to the conclusion that more land should be purchased at the earliest possible moment.

Demonstration. — There are two rather distinct types of demonstration: the one having for its object teaching a lesson concerning the value of a line of practice, already fully established as sound, for the purpose of impressing the farmers in the locality in which it is located with the fact of its importance to them; the other designed to test the validity of results of research or experiment in our own or other stations under varying conditions affecting soil, local climate and economic result upon the farms in different sections of the State.

Demonstration of the first kind is properly the function of the extension service; that of the second kind is more legitimately the work of the experiment station, for it is experimental in nature and will result in broadening the field of knowledge. New and more or less untried methods or modifications of old methods, new crops or varieties, new insecticides and fungicides, new fertilizers, or new methods of employing fertilizers, are a few among many subjects which may appropriately be made matters for station demonstration.

There is one line of experimental demonstration in particular which is urgent, both because of its vital importance in the agriculture of the State and because the station has been strongly urged to undertake it. I refer to methods of pasture improvement. The experiment station has obtained some very striking results in the use of fertilizers. It is important that the extent to which similar results may be anticipated on different types of soil be investigated; and that the question as to whether pasture improvement by such use of fertilizer or by other methods which are in need of investigation can be made profitable. The pastures of the State stand in great need of improvement. Our live stock ranges over wide areas to obtain, in too many cases, only a scanty subsistence. The production of milk in the State has rapidly fallen off during recent years, no doubt in considerable measure because of the poor condition of our pastures.

Moreover, the high prices now ruling for meats make it seem highly probable that the time has come when, with intelligent improvement of pastures, the State might wisely produce a much larger share of the meat consumed by its inhabitants. It seems entirely possible that steers and sheep can be profitably fattened in the State even if they can be reared to the fattening age more cheaply in other parts of the country. There is, however, a question whether even the production of well-bred stock to the fattening age may not be successfully carried on. Our soils and climate are admirably adapted to the production of pasture forage. An appropriation for the purpose of undertaking extensive demonstration experiments in pasture improvement is highly desirable.

The Attitude of the Station toward Private Work.

That the most important function of the experiment station is the public service is generally recognized. It is also generally recognized that its principal work should be investigation, with a view to gaining new knowledge of fundamental laws and principles bearing upon the art of agriculture, and experiment, which has for its object the discovery of new applications of known laws and principles and better methods, both in the practice and business transactions of the farm and garden. The results of its investigations must of course be published and disseminated. In addition, this experiment station is charged with the execution of important control laws, — those relating to the manufacture and sale of commercial fertilizers and commercial feedstuffs, and the dairy law.

The cost of the work connected with the execution of these laws is covered by funds especially provided therefor. It makes no draft upon the funds appropriated for investigation, and the work is in the hands of a special staff which would not otherwise be employed. This work, therefore, does not lessen station capacity for investigation and experiment. On the other hand, as has been pointed out under the topic "Maintenance," since unexpended balances are available for certain kinds of experiment, our resources for investigation are somewhat increased because of the fact that the station is charged with the execution of these laws.

There are, however, constant and insistent requests for services which lie outside of the fields which have been designated, many of which are more or less private in character. To meet these requests would consume a large share of the time and energy of the members of our staff, and must greatly lessen their capacity for research. Not a few of these services are routine in nature, the same service is requested over and over again by different individuals, the results often have a transient value only, and it may be only to the individual requesting it. To use public funds for private work, especially in view of the fact that the public service must suffer if it is undertaken, would clearly be a mistake in policy.

Having thus endeavored to make the underlying principle and its reasonableness clear, a statement in detail of our attitude in relation to some of the kinds of service most frequently called for, with the special reasons therefor, seems desirable.

Chemical Analyses for Individuals. — Numerous requests for chemical analyses come to the station annually from individuals. There is hardly a substance of any possible interest to our citizens which we are not yearly asked to analyze. Soils, fertilizers, feeds, drinking waters, milk and cream, vinegar, drugs, minerals, and the viscera of animals supposed to have been poisoned are some of those most frequently sent in. Not a few individuals appear to regard such work as a proper function of the experiment station; occasionally one represents that as he is a taxpayer he has a right to such service, overlooking the fact that taxes are assessed to support public work, not to pay for private service. The majority, on having their attention called to the distinction referred to, take a correct view of the matter.

Many offer to pay the costs of analysis. The station is not organized for commercial work. Such work would almost inevitably interfere with more legitimate work, unless, indeed, a staff of chemists who should be employed in commercial work only should be maintained. This policy cannot at present be carried out. It would require separate laboratories, and it is not sufficiently constant to afford regular employment. Fortunately, there is little occasion for the establishment of a State

laboratory for commercial work as there are numerous and reliable private commercial chemists. Further, there will be general agreement that for a State institution to engage in commercial work would be an unwise intrusion in a field where the rights of private enterprise would be infringed. The station, as a rule, does not (drinking waters excepted) accept compensation for any chemical analyses which it may undertake.

Analyses of Fertilizers or Feeds for Manufacturers or Dealers. — Under no circumstances can the station undertake chemical analysis as one of the necessary steps for manufacture or as a basis for guarantees. It should not and will not assume this responsibility.

Analyses of Fertilizers and Feeds for Consumers. — Not infrequently buyers send in samples, with the request that we determine the composition. It is contrary to sound policy, as a rule, to make such analyses, for two reasons: —

1. The materials in almost all cases are sampled in the course of the regular inspection and analyzed. A repetition is uncalled for.

2. It is not certain that these samples are properly taken, for to secure a thoroughly representative sample requires special instruction and experience. No suit nor claim for shortage can be based upon an analysis of a sample not officially taken.

In all cases, however, where either fertilizers or feeds are purchased on guarantee, with a definite understanding that the price shall be determined on the basis of analysis, the station is prepared to sample the goods where the transaction is of sufficient magnitude to warrant the expense, and will make the required analysis. Further, in the case of feeds it is sometimes possible, by mechanical separation and examination under low magnifying power (processes which can quite easily be carried out), to determine the ingredients, and such work the station will do on request.

Analyses of Soils. — The number of letters received asking for instruction in relation to sending samples of soil to be analyzed for the purpose of determining what fertilizers should be used, and the number of samples of soils sent in for such analysis for that purpose without previous inquiry, is con-

stantly increasing. For this reason, although this matter is somewhat fully discussed in the twenty-first annual report, it seems necessary to refer to it again. There is widespread misapprehension as to the value of the chemical analysis of soils. It seems to be very generally believed: —

1. That chemical analysis will show to what crop a soil is suited.

2. That such analysis will determine what fertilizer should be applied and the quantities needed.

It seems also to be generally believed that the cause of crop disease will be revealed by a chemical analysis of the soil in which the crop is growing.

None of these views is justified by the facts. While the chemical condition of a soil is not altogether without influence in determining the crops to which it is suited, crop adaptation, at least within such range of soil variation as exists in this State, is determined in far greater degree by physical and drainage conditions. Neither does the chemical analysis of the soil show what fertilizers should be applied. Such analysis will determine with exactness the proportion of the several elements present, but it cannot show to what extent these elements are available; indeed, there is no such thing as a constant ratio of availability. The capacity of different crops to extract food from one and the same soil varies widely, and fertilizer requirements are determined in far greater degree by crop than by condition of the soil, within such limits of variation as are usually found in the soils of this State.

Occasionally a faulty chemical condition is responsible for an abnormal or unhealthy condition of the crop, but in most cases the immediately active cause of plant disease is the presence of a parasitic fungus, and this fungus is usually capable of fixing itself upon the plant, whatever may be the composition of the soil.

For the reasons briefly stated the chemical analysis of soils does not, as a rule, afford results which have a value commensurate with the cost, and this station will not, therefore, make such analysis unless a soil differs widely from the normal in natural characteristics, or has been subjected to unusual treatment of

such a nature as to probably greatly influence its chemical condition.

In this connection attention is called to the fact that the most satisfactory means of determining the fertilizer requirements of crops is by carrying out a simple but carefully planned experiment in the field; and in all cases the station is glad to advise in relation to such experiments. It will furnish plans on application, provided the general conditions and the crops to be grown are indicated.

Water Analyses. — Properly taken samples of drinking water will be given a sanitary analysis, for which a uniform charge of $3 is made. This charge hardly equals cost. It is much below the usual figure for such work, which probably averages at least $10. A small charge was found to be necessary in order to prevent the indiscriminate forwarding of samples in such number as to constitute a serious burden, and in many cases when conditions hardly suggested any necessity for such analysis.

Analyses of Milk and Cream. — For the present, as has been our practice for some years, the station will analyze properly taken and preserved samples of milk and cream for fat and total solids, free of cost. This is done because facilities for such work are seldom within the reach of farmers, in order that it may be more fully recognized that the value of the product is not determined solely by the number of quarts or pounds of milk produced.

Foods and Drug Analyses. — This experiment station does not, under any conditions, undertake analyses of foods or drugs. It is not charged with the execution of the pure food law. That work in this State is looked after by the State Board of Health.

Personal Inspection of Farms or Lands. — Quite frequently a letter is received asking the station to send some one for the purpose of looking over a farm and advising in relation to its value or management, or for the examination of a certain tract of land, perhaps with reference to the possibility of its improvement, or for the purpose of determining what crops it is suited to. The station organization does not at present include men whose time is free for work of this description. Such work,

moreover, is private in its nature; it is in the interest of individuals and not in the interest of the public; and it is doubtful whether, therefore, it is a proper function of the experiment station. Special trips for the examination of farms or tracts of land will not, therefore, be undertaken. We do constantly advise in relation to farm problems which are clearly and definitely brought before us, and members of the station staff make many visits to farms, orchards, gardens and hothouses for the study of important problems when the solution is likely to be of public as well as of private interest.

Station Literature. — It appears to be generally thought that the station is prepared to furnish comprehensive manuals on all subjects related to rural life. We constantly receive requests which begin: "Please send me your book, or your treatise, on ," and such subjects as potatoes, corn, strawberries, asparagus, cranberry culture, soils, drainage, etc. follow. The preparation of such manuals involves compilation rather than investigation. It is the latter for which the station is maintained. If distribution of such manuals is a proper function of any branch of an agricultural college it is that of the extension department rather than of the station. The station is not a publishing house. It is true that in connection with the report of the results of investigations it sometimes seems best to outline existing conditions, practices and opinions. In so far as this assists in correlating new results with earlier practice it is legitimate in a station publication, and some of our publications, therefore, may be valuable as a fairly comprehensive general guide to practice, but funds placed at the disposal of the station for investigation should not be, and are not, used for the preparation of exhaustive manuals.

CONTROL WORK.

No change has been made in either of the control laws with the execution of which the experiment station is charged. The regular inspections of fertilizers, feeds and dairy apparatus have been carried out without incidents requiring special mention. The amount of this work steadily increases, especially

in connection with fertilizers and feeds, with the multiplication of brands. The comparative number of official samples for the past few years clearly shows this growth.

Number of Official Samples.

Year.	Fertilizers.		Feeds.	
	Brands.	Samples.	Brands.	Samples.
1909,	458	1,052	196	895
1910,	487	890	195	946
1911,	519	1,063	204	1,055
1912,	527	1,180	194	902
1913,	571	1,299	227	1,115

The table shows the number of brands of complete fertilizers and agricultural chemicals sampled in the State during each of the years since 1909. In that year the total number was 458; in 1913 it had grown to 571. In the latter year the number of brands of potato fertilizers offered for sale in the State was no less than 90. It is not easy to say, since registration has only recently been required, how many kinds of feed mixtures are offered for sale in the State, but the number is clearly very large. This matter is referred to for the reason that there can be no question that the continued multiplication of brands of fertilizers and feed mixtures increases the cost to the consumer, who in the last analysis must pay the costs of advertising, agencies, analyses, etc. The greater the number of kinds the greater these costs, and therefore, unless the kinds so differ from each other that each fills some special need or requirement which no other could fill equally well, this constant multiplication of kinds is to be deprecated. There are without doubt many more kinds, both of fertilizers and feeds, offered in our markets than are needed. No one will attempt to maintain for a moment that we need ninety kinds of potato fertilizers, nor is it possible that we need nearly six hundred different brands of fertilizers or over two hundred kinds of feeds. A reduction in the number would be a distinct advantage, both

to manufacturers and dealers on the one hand and to consumers on the other.

Detailed reports on the control work will be found in the report of the chemist, Dr. J. B. Lindsey.

LINES OF WORK.

The lines of experiment and research followed for the past few years, and referred to in recent reports, have been continued. One new research problem has been taken up. This is in the poultry department. Provision for a breeding house was made by legislative appropriation in 1912, and with the coming of Dr. Goodale in February a study of some of the more important problems connected with the inheritance of such charcteristics as fertility, hatchability and fecundity was begun.

Another new line of inquiry has been undertaken during the year. This was made possible only by the rental of land for the purpose. The work in view is to determine by most careful experiment the rate of availability of the phosphoric acid of basic slag meal. The experiment is part of a plan recommended by the committee appointed by the Association of Official Agricultural Chemists. Thirteen other experiment stations are co-operating. This work is in direct charge of our fertilizer chemist, H. D. Haskins.

General Experiments.

An idea of the general work may be gained from the following enumeration of the principal lines of inquiry. These are: —

Soil tests with fertilizers with different crops in rotation; comparison of different materials available as sources, respectively, of nitrogen, phosphoric acid and potash for both field and garden crops, with a view to determining the ultimate effects of each on soil chemistry, biology and physics; results of the use of different forms of lime; systems of fertilizing mowings and orchards; trial of different manures and fertilizers for both tree and bush fruits; methods of applying manures;

variety tests of garden and field crops and of fruits; tests of different spray materials; comparison of methods of pruning; comparison of cover crops in orchard management; tests of southern *versus* northern nursery stock; of one and two year old apple trees; tests of trees pruned and not pruned at setting time; trials of new crops; determinations of the digestibility of feedstuffs; methods of feeding for milk; systems of feeding and management of poultry for eggs; tests of the efficacy of anti-hog cholera serum; studies upon the diagnosis and transmission of avian tuberculosis; co-operation with selected farmers in the trial of crops and systems of fertilizing them.

We have two substations, one for investigations connected with asparagus at Concord, the other for cranberry investigations in Wareham. Brief references to the work at these stations will be found later in this report.

Research.

The research problems under investigation are for the most part supported by the Adams fund, and have received the approval of the Office of Experiment Stations. The principal problems at present under investigation are the following: —

1. To determine the principles which should underlie practice in the use of fertilizers for the cranberry crop.

2. To determine the principles which should underlie practice in the use of fertilizers for asparagus.

3. Work in plant breeding in the endeavor to produce more rust-resistant types of asparagus. (In co-operation with the Bureau of Plant Industry, United States Department of Agriculture.)

4. Investigation of the solubility effect of ammonium sulfate on the soil of one of our experimental fields (Field A).

5. The effect of food on the composition of milk and butter fat and on the consistency or body of butter.

6. The cause of the digestion depression produced by molasses.

7. Why insecticides burn foliage.

8. Effects of meteorological conditions on the development of plants and crops, both in health and disease.

9. Influence of soil moisture on seed germination.

10. Relation of light to burning from spraying with fungicides and insecticides.

11. Nature and cause of burning from fumigation with various gases.

12. Effects of electricity on nitrogen fixation in soils and in stimulating plants in general.

13. Relation of light to burning of vegetation from miscible oils.

14. Study of interrelation of stock and scion in apples.

15. Plant breeding, especially with peas, beans and squashes, to determine the extent to which the Mendelian laws appear to govern heredity.

16. The relation of climate to variation in leading varieties of apples.

17. The economic importance of digger wasps in relation to agriculture.

18. Color vision in bees.

19. The diagnosis of white diarrhœa in adult fowls.

THE ASPARAGUS SUBSTATION, CONCORD.

The year 1913 at the Asparagus Substation in Concord was highly successful from the experimental point of view. Mr. Prescott continued his effective service in general local charge, and Mr. J. B. Norton of the United States Department of Agriculture, his enthusiastic breeding work. It will be remembered that the experiments at this substation are in two distinct lines: a study of the plant-food requirements of the crop and, second, breeding experiments with a view to the production of a rust-resistant type.

Plant-food Requirements.

The crop on the plots where the fertilizer experiments are located was the best produced in their history. The average yield per plot in 1912 was 278.5 pounds; in 1913 it was 374.9 pounds. The rate of yield per acre in 1912, 5,570 pounds; in 1913, 7,498 pounds. The average yield per plot in 1913 was,

therefore, about 100 pounds greater than in 1912; the rate per acre in round numbers, one ton greater in 1913 than in 1912. The larger yields in 1913 were doubtless due in considerable measure to the fact that there was but little rust in 1912. It is thought that the specific effects of the different fertilizer elements and combinations, therefore, are shown much more clearly in the yields obtained in 1913 than in any previous year. It is not the purpose at this time to report either the plan of the experiment or the results in detail; but the following general conclusions appear to be warranted:

A fairly liberal use of chemical fertilizers is as effective to date in increasing yield as a combination of manure and fertilizers.

Effect of Nitrate of Soda as a Source of Nitrogen. Nitrate in Connection with Mineral Fertilizers (Acid Phosphate and Muriate of Potash). — Nitrate of soda greatly increases the crop, but a quantity in excess of the rate of 300 pounds per acre has not so far seemed to be beneficial, and in a considerable number of instances the minimum application (at the rate of 200 pounds per acre) has given a crop as good or even slightly better than any larger amount.

Season of Application of Nitrate. — Nitrate of soda in these experiments is applied in equal amounts in three different methods as regards season: —

(*a*) All in the early spring.

(*b*) Half in the early spring and half after the cutting season is ended.

(*c*) All after the cutting season is ended.

The results indicate a moderate degree of superiority for a method of application in which a portion at least of the nitrate is applied after the cutting season. This superiority shows itself both in slightly larger yield and in apparently making the crop somewhat more resistant to rust.

Nitrate in Connection with Manure. — In the case of all plots top-dressed with manure at the rate of 20,000 pounds to the acre the application of nitrate also has resulted in a distinct gain in yield, which, however, reaches its maximum on the medium quantity of nitrate (300 pounds per acre).

When nitrate is used in connection with manure (as in the other combinations referred to) summer application or divided spring and summer application gives results rather better than spring application.

Complete Chemical Fertilizers in Connection with Manure. — A mixture of chemicals, making what may be called a complete fertilizer (nitrate of soda, acid phosphate and muriate of potash), used in connection with manure at the rate of 20,000 pounds per acre, produced a moderate increase in crop, but the increase produced has not been as great as that produced by the use of nitrate alone in connection with the same amount of manure. The fact that the increase on the complete fertilizer is less than that produced by nitrate alone is probably not significant; but since it is no greater, the conclusion is apparently justified that the use of the acid phosphate and muriate of potash in connection with manure has not been beneficial.

Effect of Acid Phosphate. — The addition of acid phosphate to a combination of nitrate of soda and muriate of potash, furnishing adequate quantities of nitrogen and potash, has but little effect upon the crop.

Effect of Potash. — The use of muriate of potash in connection with a mixture composed of nitrate of soda and acid phosphate in adequate amounts greatly increases the crop, but a quantity in excess of 300 pounds to the acre has not been beneficial.

Comparison of Different Materials as a Source of Potash. — Muriate of potash is used in these experiments as the source of potash on almost all plots, but for the purpose of comparison one plot for each is introduced where the source of potash is different. The materials under comparison are wood ashes, kainit, high-grade sulfate of potash and low-grade sulfate of potash (potash-magnesia sulfate). The yield on all of these materials is considerably less than on the muriate of potash, but the kainit is considerably superior to the ashes or either of the sulfates. It is important, however, to call attention to the fact that it seems likely that the yield on the plots receiving

ashes and the sulfates of potash is slightly decreased by the neighborhood of an oak tree, which stands about two rods distant from one end of the field.

General Conclusion. — The general conclusion is at least strongly suggested that in common practice among the asparagus growers of the State chemicals are frequently used in quantities in excess of those which are required to produce maximum crops.

Breeding Experiments.

The new types of asparagus produced by the crosses made by Professor Norton, and referred to in previous reports, have not been subjected to tests as severe as Professor Norton has desired during the past two years since rust has been less prevalent than usual. So far as can be judged, however, the best rust-resistant types fully retain their valuable characteristics. Numerous other crosses which are promising have been made.

We have experienced great difficulty in our efforts to produce seed from the more desirable breedings, owing to the ravages of the asparagus beetle (*Crioceris 12-punctata*), which preys both on foliage and directly upon the berries. Thus far no thoroughly satisfactory method of protection has been discovered. This fact will necessarily make the time when we shall be ready to distribute seed for trial later than we had hoped, and we are unable at present to announce when such distribution will be possible, nor can we state the basis on which any distribution will be made. Clearly, however, the new types must be so handled as to insure the multiplication of those which seem most desirable as rapidly as possible in order that they may be available at an early day for test under a wide diversity of conditions.

CRANBERRY SUBSTATION, WAREHAM.

A full report on the experimental work of the past year will be found in Bulletin 150 (Part II., page 37), which is a part of this annual report. Bulletin 150 also contains a paper by Professor Morse on the composition of bog waters (Part II., page 62).

The bog produced a very superior crop in 1913, both as to quantity and quality of the fruit. The accounts are so kept as to make it possible to distinguish between such expenses as would be required in ordinary bog management and such as are incurred in connection with the experiments in progress. The area of the bog is, in round numbers, twelve and one-half acres. The two financial statements follow: —

Bog Account.

Maintenance: —		
Tools and similar equipment bought or repaired,	$94 29	
Oil for engines, etc. (gasoline, kerosene and lubricating),	96 09	
Engine and bog pump repairs,	173 95	
Pumping labor,	84 10	
Bees, rental of,	6 00	
Mowing of upland,	57 35	
Weeding,	26 50	
Fertilizers,	49 20	
Mending dikes,	3 50	
Digging out ditches,	14 00	
Repairs to buildings,	1 95	
Lumber,	7 96	
Sundries,	27 10	
Miscellaneous labor,	50 15	
Raking vines after picking,	31 72	
		$723 86
Harvesting: —		
Picking,	$500 46	
Separating,	131 69	
Screening,	119 08	
Packing,	45 75	
Carting,	132 65	
Packing materials (barrels and coopering),	538 75	
		1,468 38
Contingent expenses,		3 38
Improvements: —		
Building roads,		42 40
Total,		$2,238 02

Experimental Account.

Experimental: —		
Labor,	$422 42	
Supplies and apparatus,	279 23	
Spraying materials,	10 10	
Fertilizers,	9 37	
		$721 12
Stationery and postage,		43 95
Traveling,		35 22
Contingent: —		
Freight,	$8 02	
Express,	7 15	
Surveying,	5 00	
Carting,	14 40	
Telephone,	27 11	
Painting,	9 50	
Lumber,	18 75	
Incidentals,	1 92	
Carpentering,	4 12	
		95 97
Furnishings,		1 25
Total,		$897 51

The total sales for the year were as follows: —

Fruit,	$6,667 22
Vines,	19 65
	$6,686 87

The total receipts for products sold amounted to $6,686.87. The total ordinary bog expenses were $2,238.02. Receipts for products sold, therefore, exceeded ordinary expenses to the amount of $4,448.85. It will be seen that the bog during the year has furnished a large surplus, available to help cover the costs of experimental work. The total experimental expenses shown in the above table amount to a little less than $900, but this, it should be pointed out, does not include the salary of the superintendent. Even with this included the bog during the past year is somewhat more than self-supporting, but at-

tention is here called to the fact that cranberry bogs show a marked tendency to heavy fruit production in alternate years only. The product of 1912 sold for $1,069.87. If the two years, 1912 and 1913, then be included, the bog does not produce sufficient income to cover both ordinary and experimental expenses, and it can hardly be anticipated that over a series of years it will do this, although undoubtedly it will carry a considerable share of such expenses unless the scope of our work be greatly increased, as compared with that at present carried on.

During the past year Dr. Franklin has continued to co-operate with the United States Weather Bureau at Boston in weather observations, with a view to collecting data which shall be useful in forecasting frosts. He believes that substantial improvement has been made. At the same time important experiments on methods for frost protection have been in progress. The Skinner system of sprinkling has been tested, with unfavorable results. Other methods are suggested, among them protection from the early morning sun by smoke or some other screen, which method, however, has not been fully tested.

The value of keeping a bog well sanded as a means of frost protection is pointed out.

Co-operative work with the United States Department of Agriculture, which is represented in such work by Dr. Shear, has been continued. The results do not clearly indicate that the systems of spraying which were tried were efficacious.

Copper sulfate in different proportions in the flowage water has been tested as a fungicide. The results were not favorable.

Preliminary work looking toward the possible development of varieties superior to those now generally cultivated has been begun, — a line of work which should prove of much value.

The relation of insects, especially the honey bee, to the pollination of the flowers has been further studied, the results fully confirming those previously obtained. The cranberry appears to be dependent upon transfer of pollen by insects, and the honey bee is undoubtedly one of the most important among such insects.

Fertilizer experiments were continued, the application of

materials being deferred until July 15, with a view to avoiding the possible loss through reflowage, which it was believed might be necessary up to that date for protection from insects or frosts. There was no increase in crop as a result of the application of any of the fertilizers; indeed, the fertilized plots gave somewhat smaller yields than the unfertilized. Whether this was due to the lateness of the application is uncertain. The result is, however, the opposite to that which was obtained in 1912.

A large part of the work of Dr. Franklin has consisted in further study of the various insects which affect the crop. The observations made and the results obtained are fully set forth in Dr. Franklin's report. Among the more important conclusions which appear to be justified are the following: —

Careful observations have been made on a span worm (*Epelis truncataria* var. *faxonii* Minot). The pupæ are not destroyed by winter flowage. Heavy sanding kills most of them. In cases of very heavy infestation burning over the bog may be the best course to take in order to get rid of the insect.

Observations and further experiments on the flowed bog fireworm (*Rhopobota vacciniana* (Pack.)) indicate that late holding of the winter flowage (until about June 1), and reflowing about three weeks later, is an effective means of destroying this insect. Spraying with arsenates is also useful, but whether arsenate of lead or Paris green should be preferred is not yet certain, although it is believed that the arsenate of lead is the better of the two. There appears to be a considerable difference in the extent to which different varieties are attacked by this insect, the Late Howe being much more seriously injured than the Early Black.

A number of important parasites of the fruit worm (*Mineola vaccinii* (Riley)) have been discovered and studied. The most important among them appears to be *Phanerotoma tibialis*. Just how important this will prove to be in helping to control the fruit worm is not yet clear. Observations indicate that parasites are much more abundant on dry bogs than on those which are flowed.

Flowage experiments indicate that fall flowage, whatever the depth, is not effective in destroying the fruit worm. Experi-

ments on dry bogs indicate that resanding is not an effective method, and the suggestion is made that in case of very heavy infestation the destruction of all the bloom by spraying with a solution of iron sulfate will be an effective means of starving out this insect in a bog so treated.

Experiments on weed destruction by spraying with iron sulfate indicate that a 20 per cent. solution is fairly effective in killing the tops of horsetail (*Equisetum*), but the roots were not killed; and Dr. Franklin is not ready to recommend repeated use of such a solution, as it is possible that in large amounts it will prove injurious to the cranberry itself.

Copper sulfate dissolved at the rate of 1 pound to 25 gallons of water injected into holes in the bogs proves ineffective.

Careful observations upon the fruit produced by plots respectively untreated and resanded indicated that resanding injures keeping quality.

Professor Morse's work in the study of the water from cranberry bogs indicates that the composition of this water was not affected to an appreciable extent by the varying fertilizer treatment of the different bogs. His observations further indicate that vine growth is affected in greater degree by varying drainage conditions than by variation in fertilizer applied. The greatest vine growth was obtained in the bogs through which the water moved with greatest freedom.

INVESTIGATION.

In the agricultural department of the experiment station the lines of experimental work pursued have been similar to those followed for the last few years, but supplemented more and more fully by correlated chemical studies. In this work the usual number of field and closed plots has been employed. The number of pot experiments has been less than usual, owing to the absence of the director during the early part of the year. Attention will be here called to a few only of the results which seem most fully established.

High-grade sulfate of potash combined with bone meal continues to show itself superior to muriate in the same combina-

tion for alfalfa, raspberries, blackberries and rhubarb. The rates of yield per acre for these crops on the two potash salts under comparison during 1913 were as follows: —

	Muriate of Potash.	Sulfate of Potash.
Rhubarb (pounds),	17,913	24,174
Blackberries (pounds),	6,162	8,263
Raspberries (pounds),	2,068	2,683
Alfalfa (tons),	3.7	4.2

Muriate of potash, on the other hand, gives much larger yields of asparagus than the sulfate, both being used with equal quantities of bone meal. The rates of yield per acre are as follows: —

	Muriate of Potash.	Sulfate of Potash.
Asparagus (pounds),	6,927	6,007

The combination of low-grade sulfate of potash with bone meal continues to give larger yields of apples than muriate in such quantities as to furnish equal potash in the same combination. The yield of apples under the different fertilizer treatments in the season of 1913, and the total yields to date, are shown in the following table: —

Yield of Apples (Pounds).

	Plot 1, Manure.	Plot 2, Ashes.	Plot 3, Nothing.	Plot 4, Muriate of Potash and Bone.	Plot 5, Sulfate of Potash and Bone.
1913,	7,977	4,954.5	3,032	6,233	7,992
Totals to date,	41,547	25,226.0	10,148	23,360	34,663

As in previous years the three Gravenstein trees in the sulfate of potash plot gave a smaller yield in 1913 than the three Gravenstein trees in the muriate of potash plot, a result perhaps

due to the proximity of the trees in the sulfate of potash plot to a neighboring forest.

Some fire blight showed itself in this orchard during the past season. The several plots in severity of blight injury ranked in the following order: 4, 5, 1, 2, 3. The Greening variety showed more blight than any other in all the plots except No. 5, in which the Gravenstein showed rather more than the Greening.

In the south soil test, where each plot has been continuously fertilized in the same way for twenty-five years, the crop in 1913 being corn, muriate of potash showed itself to be much superior to either nitrate of soda or acid phosphate in its effect upon that crop. The average rates of yield per acre on the nothing plots were: —

	Hard Corn (Bushels).	Soft Corn (Bushels).	Stover (Pounds).
Nothing plots,	2.2	7.9	1,870

The rates of yield on the different fertilizer combinations were as follows: —

	Hard Corn (Bushels).	Soft Corn (Bushels).	Stover (Pounds).
Nitrate of soda alone,	7.7	14.9	2,420
Dissolved boneblack alone,	1.3	9.7	2,180
Muriate of potash alone,	44.9	7.7	4,360
Nitrate of soda and muriate of potash,	46.9	4.3	3,500
Dissolved boneblack and muriate of potash,	44.6	5.1	4,040
Nitrate of soda, dissolved boneblack and muriate of potash,	40.0	4.4	3,840

It will be noted that only where potash is used is there any considerable increase in the crop.

In the north corn acre the fertilizer combination richer in potash gives a rather higher yield of hay than the combination relatively low in potash and high in phosphoric acid, which is similar in composition to the average of the corn fertilizers offered in our markets. This is the twenty-third year of this experiment.

On the south corn acre manure alone at the rate of 6 cords per acre gives about 600 pounds more hay than the combination of 4 cords of manure and 160 pounds of high-grade sulfate of potash. This is the twenty-fourth year of this experiment.

In the experiment comparing different phosphates used in such quantities as to furnish equal phosphoric acid, which has been in progress since 1897, the crop this year was corn. The apparent effects of the different phosphates upon the crop are shown in the following table: —

	Gain or Loss.	
	Corn (Bushels).	Stover (Pounds).
Plot 1, no phosphate,	-	-
Plot 2, Arkansas rock phosphate,	—1.9	+240
Plot 3, South Carolina rock phosphate,	—2.2	+720
Plot 4, Florida soft phosphate,	—0.2	+720
Plot 5, basic slag meal,	+6.1	+736
Plot 6, Tennessee rock phosphate,	+1.9	+720
Plot 7, no phosphate,	-	-
Plot 8, dissolved boneblack,	+3.5	+720
Plot 9, raw bone,	+7.3	+1,160
Plot 10, dissolved bone meal,	+14.3	+920
Plot 11, steamed bone,	+15.2	+1,240
Plot 12, acid phosphate,	+10.6	+1,320
Plot 13, no phosphate,	-	-

It will be noted that the effect of the untreated rock phosphates upon the yield of grain is extremely small, there being in most cases a slight decrease. On the other hand, the bone meal, both raw and steamed, the basic slag and the superphosphates (dissolved boneblack, dissolved bone meal and acid phosphate) all give moderate increases. There is an increase in stover in all cases, but materially smaller on the untreated rock phosphates than on most of the others.

The crop of grain was undoubtedly smaller than it otherwise would have been because of the effects of the heavy frost which came just before the middle of September, at which time the ears were not mature. This frost killed the leaves of the plants

and the outer husks of the ears, but did not entirely check their development. There was, however, a large proportion of soft corn. The proportion of soft corn on the basic slag meal was least, and in general less on the soluble than on the more insoluble phosphates. The effect of the fertilizer, however, is undoubtedly somewhat obscured by the fact that there is a gradual increase in the proportion of clay in the soil from plot 1 toward plot 13. This difference makes the soil colder at the end of the field, where the more soluble phosphates were used, than at the other end, and this condition undoubtedly tended to increase the proportion of immature corn.

The percentage of soft or immature corn as compared with sound corn on the several plots is shown below: —

Percentage of Soft Corn as compared with Sound.

Plot 1, no phosphate,	48
Plot 2, Arkansas rock phosphate,	66
Plot 3, South Carolina rock phosphate,	87
Plot 4, Florida soft phosphate,	48
Plot 5, basic slag meal,	30
Plot 6, Tennessee rock phosphate,	51
Plot 7, no phosphate,	84
Plot 8, dissolved boneblack,	86
Plot 9, raw bone,	58
Plot 10, dissolved bone meal,	44
Plot 11, steamed bone,	52
Plot 12, acid phosphate,	67
Plot 13, no phosphate,	80

In the experiment in top-dressing mowings with different materials used in rotation since 1895 the crop was much below the average on account of the great deficiency in rainfall, especially during the latter part of the season. The rates per acre were as follows: —

	Hay (Pounds).	Rowen (Pounds).
Plot 1, bone and potash,	4,117	963
Plot 2, slag and potash (in place of ashes used in earlier years),	3,604	710
Plot 3, manure,	3,522	720

In this field two different seed mixtures, referred to in previous reports respectively as the "fescue mixture" and the "timothy mixture," are under comparison. The "fescue mixture," as has been true for the past few years, gave a considerably larger crop than the "timothy mixture."

The chemical department during the past year has published one bulletin, "The Record of the Station Herd and the Cost of Milk Production." This shows that the larger cows produce milk at lower cost than the smaller, and the conclusion drawn from the records (which are exact as regards food consumed and milk yield, but necessarily estimated as regards labor and some other items) is that milk of satisfactory quality can probably not be produced and sold at the farm at a profit at less than from 5 to 5½ cents per quart.

The chemical department has published a bulletin, "The Digestibility of Cattle Foods," found later in this report. In this will be found the results obtained in a large number of digestion experiments.

The chemical department has continued the study of the effects of food on the composition of milk. In this connection it has been found necessary, for accurate determination of the chemical composition of butter fats, to discover and perfect new methods and apparatus. A bulletin, "The Determination of the Acetyl Number," found later in this report, describes one of the improved methods. Some new forms of apparatus and other methods now under trial are highly promising and will be described in later papers.

The study of the composition of asparagus shoots and tops at successive stages of growth has been continued in connection with our study of the nutrition of this plant. Up to the present time no clear relation between fertilizer treatment and composition has been proved.

Cranberry nutrition studies have been continued, the composition of the waters of the small artificial bogs established at the station receiving particular attention. A paper on this subject will be found in a bulletin in later pages, "Reports on Experimental Work in Connection with Cranberries."

In the continued study of the effects of sulfate of ammonia on the soil it has been found that its use as a fertilizer seems

to cause a large removal of calcium in the drainage waters, and it seems probable that the so-called acidity of soils fertilized with this substance is due, in part at least, to the solvent action of the ammonium sulfate on the calcium.

It has been shown in the feeding experiments carried on in this department that fish meal may be used as a source of a part of the protein in the ration for dairy cows, although, owing to the cost of such meal, it is doubtful if this would be the most profitable practice.

Extensive experiments with Molassine meal have shown that at usual relative prices it is not an economical food for cows.

The report of the chemist, found in later pages, discusses these matters in greater detail. In this report will be found also a fuller statement than that found earlier in this report of the work of the fertilizer, feed and dairy sections of the department, as well as a brief account of its general analytical and other work.

The botanical department has published a bulletin, "The Relation of Light to Greenhouse Culture." This presents the results of numerous experiments, which clearly show the close relation of varying light conditions to the development and health of crops. Upon these results are based important recommendations as to the location and construction of greenhouses.

The principal line of investigation followed in the department for several years — the effects of environment upon the growth of plants and crops, both in health and disease — has been continued.

A new form of spray nozzle, which is unusually efficient at a considerable distance from the point of discharge, has been perfected and patented.

Another subject which is receiving careful investigation is the relation of light to burning, following application of miscible oils.

The report of the botanist, found in later pages, discusses the matters here referred to in greater detail.

The investigation work in the poultry department has been well started. The principal line of work in progress is a thorough study of the capacity of each hen in a carefully se-

lected breeding flock of 144 birds to produce: (*a*) eggs, (*b*) fertile eggs, (*c*) hatchable eggs, (*d*) viable chicks, (*e*) vigorous adults; and of the ability of each hen to transmit these qualities to her progeny.

In the department of pomology a bulletin, — "A Study of Variation in Apples," — found later in this report, has been issued. This bulletin presents the conclusions based on a study of climatic and other conditions upon the size, shape and other characteristics of apples. The investigation shows in general that a high temperature is favorable to the development of relatively flattened forms, and that, on the other hand, a low temperature, especially during a period immediately following the setting of the fruit, is favorable to elongated forms.

In the veterinary department methods of diagnosing infection with the bacterium which causes white diarrhœa in the chicks of the domestic fowl have been studied, and a bulletin on the subject — "On the Diagnosis of Infection with Bacterium Pullorum in the Domestic Fowl" — is found later in this report. The conclusion is that the examination of the eggs from suspected hens is not a practicable method for rapid diagnosis. On the other hand, macroscopic agglutination tests of the blood can be rapidly made and appear to give reliable indications.

In the entomological department the life history of the marguerite leaf miner (*Phytomyza chrysanthemi* Kow.) has been worked out and methods for its control discovered. Numerous insecticides have been tested. A very active and efficient parasite of the San José scale has been discovered. The work of this parasite has been found very effective, having resulted in the destruction of over 90 per cent. of the scales on the branches of trees examined in many cases. The entomologist has supplied parasitized scale to stations in a number of other States and is still supplying material on request. A fuller report concerning this scale and other work of the entomological department will be found in later pages.

The report of the treasurer immediately follows the director's report.

WM. P. BROOKS,

Director.

REPORT OF THE TREASURER.

ANNUAL REPORT

Of Fred C. Kenney, Treasurer of the Massachusetts Agricultural Experiment Station of the Massachusetts Agricultural College, for the Year ending June 30, 1913.

United States Appropriations, 1912–13.

	Hatch Fund.	Adams Fund.
Dr.		
To receipts from the Treasurer of the United States, as per appropriations for fiscal year ended June 30, 1913, under acts of Congress approved March 2, 1887 (Hatch fund), and March 16, 1906 (Adams fund),	$15,000 00	$15,000 00
Cr.		
By salaries,	$9,669 91	$12,583 58
labor,	2,319 19	931 46
publications,	386 23	–
postage and stationery,	108 45	21 16
freight and express,	6 25	14 31
heat, light, water and power,	20 76	110 94
chemicals and laboratory supplies,	99 68	514 26
seeds, plants and sundry supplies,	369 52	200 71
fertilizers,	726 47	88 05
feeding stuffs,	625 84	–
library,	118 08	22 03
tools, machinery and appliances,	204 77	5 29
furniture and fixtures,	36 25	9 00
scientific apparatus and specimens,	114 77	119 80
live stock,	6 40	–
traveling expenses,	131 13	76 61
contingent expenses,	–	–
buildings and land,	56 30	302 80
Total,	$15,000 00	$15,000 00

State Appropriation, 1912–13.

Cash balance brought forward from last fiscal year,	$6,787 28
Cash received from State Treasurer,	19,875 00
fertilizer fees,	10,444 99
farm products,	4,361 77
miscellaneous sources,	9,357 40
	$50,826 44

Cash paid for salaries,	$19,736 36
labor,	7,728 98
publications,	1,573 42
postage and stationery,	1,152 77
freight and express,	361 62
heat, light, water and power,	419 87
chemicals and laboratory supplies,	1,014 37
seeds, plants and sundry supplies,	1,104 18
fertilizers,	321 80
feeding stuffs,	893 68
library,	215 36
tools, machinery and appliances,	507 39
furniture and fixtures,	392 97
scientific apparatus and specimens,	104 40
live stock,	231 50
traveling expenses,	2,737 34
contingent expenses,	130 00
buildings and land,	625 88
balance,	11,574 55
	$50,826 44

REPORT OF THE CHEMIST.

JOSEPH B. LINDSEY.

1. Work of the Research Section.

Mr. Holland and assistant have devoted their time largely to a study of methods for a more thorough examination of butter fat in connection with our study of the effect of food upon the composition of milk. The work has been along the following lines: —

(*a*) The study of methods for the quantitative determination of the several insoluble fatty acids in butter fat. This has led to a very thorough study of the constitution of oils and fats, and resulted in a new process for the determination of hydroxy acids, both free and combined, of monoglycerides and diglycerides and of free insoluble alcohols. A paper on this subject will be published as a bulletin.

The study has led also to the development of a new process for the determination of stearic acid, which promises to be far preferable to that of Hehner and Mitchell on account of better thermostatic control during the filtration period.

The large amount of analytical work has, in itself, brought to light a mass of valuable information relative to solutions and details of manipulation which assure greater accuracy, and has resulted in a systematic correlation and standardization of the more common methods.

In addition to the above, butter fat from Jersey and Holstein cows at the beginning and end of lactation has been analyzed by recognized methods.

(*b*) The stability test with olive oil is being continued. While the physical changes are pronounced in many instances, the chemical are not sufficient as yet to merit a report.

(*c*) The work on insecticides has been comparatively light, and that largely advisory, with the exception of a careful examination of several samples of a new dry acid lead arsenate which the entomological department has tried the past season.

(*d*) Considerable time has been spent during the past year in the development of an adiabatic bomb calorimeter, in co-operation with Mr. E. A. Thompson, the able mechanic of Amherst. The apparatus is now completed and is proving quite satisfactory.

Mr. Morse and assistant have given their time to work on asparagus, cranberries, and to the action of sulfate of ammonia on the soil of field A of the station.

(*a*) The work of the past year on asparagus has been the completion of determinations of the composition of asparagus shoots and tops at successive stages of growth.

(*b*) The study of the composition of the drainage water of miniature cranberry bogs constructed on the station grounds has been continued on the same lines as last year, with still more attention to details of individual bogs.

(*c*) Effect of sulfate of ammonia on the soil. Particular attention has been given to composition of the drainage waters in field A and also to the ability of the soil in different plats of the field to absorb ammonia from the ammonium sulfate. One notes a large removal of calcium from the soils of the plats receiving ammonium sulfate. The so-called acidity of soils thus fertilized is probably due, in part at least, to the solvent action of the ammonium sulfate on the calcium.

Work in animal nutrition by Dr. Lindsey has included: —

(*a*) Digestion experiments with hay, corn meal, mangels, cabbage, cabbage leaves, Swedish turnips, Postum cereal residue, Mellin's Food waste, two kinds of fish meal and Molassine meal.

(*b*) A study of fish meal as a source of protein for dairy animals. A combination of bran, corn meal and cottonseed meal was compared with bran, corn meal and fish meal. The results indicated that it was perfectly feasible to use fish meal as a part of the ration for dairy animals; but at prices usually prevailing, it might make the ration a little more expensive.

(*c*) Molassine meal as an economic food for farm stock. The experiment indicated that, at the same moisture content, 1 ton of Molassine meal contained substantially 900 pounds of digestible organic matter, as against 1,400 pounds for corn meal. On this basis Molassine meal would have scarcely two-thirds of the nutritive value of the corn. An experiment with milch cows was made in which 4.3 pounds of corn meal were fed against 4.3 pounds of Molassine meal. The cows yielded some 14 per cent. more milk on the ration of which corn meal was a component.

(*d*) Studies have been continued on milk substitutes for dairy calves and the food cost of rearing dairy heifers until two years of age.

2. Work of the Fertilizer Section.

The principal work of the fertilizer section has been the annual inspection of commercial fertilizers. There has been a decided increase in the work of the fertilizer inspection from year to year. A larger number of commercial fertilizers has been registered, collected and analyzed during 1913 than for any previous year.

(*a*) *Fertilizers registered.*

One hundred manufacturers, importers and dealers, including the various branches of the large corporations, have secured certificates for the sale of fertilizer, agricultural chemicals, raw products and agricultural limes in the Massachusetts markets during the season of 1913. They may be classed, as follows: —

Complete fertilizers,	346
Fertilizers furnishing phosphoric acid and potash,	9
Ground bone, tankage and dry ground fish,	58
Chemicals and organic nitrogen compounds,	101
Agricultural limes,	27
	541

(*b*) *Fertilizers collected and analyzed.*

During the present season 133 towns were visited and 1,299 samples, representing 571 brands, were drawn from stock found in the possession of 381 different agents. This is 119 more samples, representing 44 more brands, than were taken during the previous year.

Seven hundred and forty-seven analyses (573 distinct brands) have been made during the year's inspection, as follows: —

Complete fertilizers,	427
Materials furnishing phosphoric acid and potash,	26
Ground bone, tankage and fish,	67
Nitrogen compounds,	95
Potash compounds,	45
Phosphoric acid compounds,	47
Lime compounds,	40
	747

The details regarding this inspection work will be found in Bulletin No. 147, published in December, 1913.

(*c*) *Other Work of the Fertilizer Section.*

Analyses were made of the ash of 4 samples of crimson clover plant and root, of 10 samples of asparagus plants and of 8 samples of tobacco leaves; 86 dry-matter determinations were also made on different field crops in connection with experimental work of this section.

In addition to the above, 326 different substances have been received from farmers, farmers' organizations and the various departments of the experiment station, and analyzed as follows: —

Fertilizers and by-products used as fertilizers,	149
Lime products,	19
Soils for lime requirement test,	68
Soils for complete analysis,	4
Dry-matter determinations,	86
	326

Considerable time has been given to co-operative work with the Association of Official Agricultural Chemists, Mr. L. S. Walker having served the association in the capacity of associate referee on phosphoric acid for the past season. In this work new methods for the analysis of basic slag phosphate have been studied, also new methods for the determination of available nitrogen and potash in fertilizers.

(*d*) *Field Experiments with Basic Slag Phosphate.*

This experiment was instituted at the request of the committee on basic slag, which was appointed by the Association of Official Agricultural Chemists for the purpose of determining, through vegetation tests, the efficiency of the phosphoric acid in basic slag phosphate.

In the fall of 1912, two acres of land, belonging to the Dillon farm, situated on the street leading from Amherst to Cushman, were leased for this experiment. It will be necessary, at first, to exhaust the soil of available phosphoric acid, which will require at least two years.

(*e*) *Field Experiments with New Mineral Fertilizer and Stone Meal.*

The field which served for this experiment was a part of the two-acre field leased from the Dillon farm and adjoining the land used for the basic slag experiment. The details of the experiment with each crop have been published in Fertilizer Bulletin No. 147.

(*f*) *Incompleted Work.*

A series of pot experiments was begun in the greenhouse during the fall and winter of 1912 to determine the efficiency of stone meal and the new mineral fertilizer as sources of plant food. At the present writing the dry-matter determinations have not been made on the crops grown, and the results will, therefore, be reserved for a future publication.

Many of the cotton mills in the eastern part of the State produce large quantities of a cotton waste product which shows, upon analysis, a considerable quantity of plant food in connec-

tion with a large amount of organic matter. An experiment was undertaken during the past season to show to what extent the product could be depended upon to take the place of manures and fertilizers. The results are not yet ready for publication.

3. Report of the Feed and Dairy Section.

(*a*) *The Feeding Stuffs Law (Acts and Resolves for 1912, Chapter 527).*

The first year's work with the revised feeding stuffs law was completed Sept. 1, 1913. There have been collected and examined, since the law went into effect, 1,115 samples, all of which practically conformed to their guarantees. The year has been considered one of adaptation to new conditions, and no prosecutions for violations of the law have been made, although where infringement of the statute was noted, attention was pointedly called to the matter through correspondence and conditions corrected. The text of the new law was published in Bulletin No. 142. Bulletin No. 146 gives the results of the inspection for 1913.

(*b*) *The Dairy Law (Acts and Resolves for 1912, Chapter 218).*

The dairy law, so called, requires that all milk inspectors and other operators who use the Babcock test as a means of determining the value of milk or cream shall secure a certificate of competency from the experiment station. It also provides that the glassware employed must be tested for accuracy by the experiment station and marked in such a way as to indicate the fact. In addition, an annual inspection of machines and apparatus in the various laboratories of the operators is required.

1. *Examination for Certificates.* — Twenty candidates were given certificates of proficiency during the year.

2. *Examination of Glassware.* — Six thousand three hundred and ninety-four pieces of Babcock glassware have been tested, of which only 34 pieces were condemned as inaccurate. The inspection shows an increasing number of 9-inch cream bottles

and of the 8 per cent. milk test bottles in use. They are more accurate than the 6-inch cream bottle and the 10 per cent. milk test bottle.

Following is a summary for the thirteen years the law has been in operation: —

Year.	Number of Pieces tested.	Number of Pieces condemned.	Percentage condemned.
1901,	5,041	291	5.77
1902,	2,344	56	2.40
1903,	2,240	57	2.54
1904,	2,026	200	9.87
1905,	1,665	197	11.83
1906,	2,457	763	31.05
1907,	3,082	204	6.62
1908,	2,713	33	1.22
1909,	4,071	43	1.06
1910,	4,047	41	1.01
1911,	4,466	12	.27
1912,	6,056	27	.45
1913,	6,394	34	.53
Totals,	46,602	1,958	4.20[1]

[1] Average.

3. *Inspection of Machinery and Apparatus.* — Mr. James T. Howard, as deputy inspector, has visited and inspected the Babcock machines and apparatus in 78 creameries, milk depots and milk inspectors' laboratories. Conditions were found much improved over those prevailing at the time of the previous inspection. In only one case was uninspected glassware found in use and but four machines were condemned. The use of the electrical tester is increasing rapidly. The larger number of the milk inspectors employ such a tester, as do also several of the milk depots. Most of the cities and larger towns are realizing the importance of safeguarding the milk supply and are giving their inspectors satisfactory equipment and well-furnished laboratories. Following is a list of creameries, milk depots and milk inspectors known to be using the Babcock test and visited by our inspector: —

1. *Creameries.*

Location.	Name.	Manager or Proprietor.
1. Amherst,	Amherst,	R. W. Pease, proprietor.
2. Amherst,	Fort River,[1]	E. A. King estate, proprietors.
3. Ashfield,	Ashfield Co-operative,	Wm. Hunter, manager.
4. Belchertown,	Belchertown Co-operative,	M. G. Ward, manager.
5. Brimfield,	Crystal Brook,	F. N. Lawrence, proprietor.
6. Cummington,	Cummington Co-operative,	D. C. Morey, manager.
7. Egremont,	Egremont Co-operative,	E. A. Tyrell, manager.
8. Easthampton,	Hampton Co-operative,	W. S. Wilcox, manager.
9. Heath,	Cold Spring,	F. E. Stetson, manager.
10. Hinsdale,	Hinsdale Creamery Company,	W. Solomon, proprietor.
11. Monterey,	Berkshire Hills,	F. A. Campbell, manager.
12. Northfield,	Northfield Co-operative,	John E. Nye, manager.
13. Shelburne,	Shelburne Co-operative,	I. R. Barnard, manager.
14. Wyben Springs,	Wyben Springs Co-operative,	C. H. Kelso, manager.

[1] Testing done at Massachusetts Agricultural Experiment Station.

2. *Milk Depots.*

Location.	Name.	Manager.
1. Boston,	Boston Condensed Milk Company,	R. Burns.
2. Boston,	Boston Jersey Creamery,	E. F. Luce.
3. Boston,	Elm Farm Milk Company,	J. H. Knapp.
4. Boston,	H. P. Hood & Sons,	C. H. Hood.
5. Boston,	Oak Grove Farm,	John Alden.
6. Boston,	Plymouth Creamery Company,	R. Gardner.
7. Boston,	Turner Center Dairying Association,	I. L. Smith.
8. Boston,	Walker-Gordon Laboratory,	G. Franklin.
9. Boston,	D. Whiting & Sons,	George Whiting.
10. Cambridge,	C. Brigham Company,	J. K. Whiting.
11. Cheshire,	Ormsby Farms,	E. B. Penniman.
12. Everett,	Hampden Creamery,	F. H. Adams.
13. Pittsfield,	H. H. Prentice & Co.,	H. H. Prentice.
14. Sheffield,	Willow Brook Dairy,	Frank Percy.
15. Southborough,	Deerfoot Farm,	C. H. Newton.
16. Springfield,	Tait Brothers,	H. Tait.
17. Worcester,	C. Brigham Company,	N. W. King.
18. West Stockbridge,	Borden Milk Company,	T. L. Roberts.

3. *Milk Inspectors.*

Location.	Inspector.	Location.	Inspector.
1. Adams, . . .	A. G. Potter.	24. Newton, . . .	Arthur Hudson.
2. Andover, . . .	F. H. Stacey.	25. New Bedford, . .	H. B. Hamilton.
3. Arlington, . . .	L. L. Pierce.	26. North Adams, . .	H. Tower.
4. Barnstable, . .	G. T. Mecarta.	27. Northampton, . .	G. R. Turner.
5. Boston, . . .	J. O. Jordan.	28. Pittsfield, . . .	E. L. Hannum.
6. Brockton, . . .	G. G. Bolling.	29. Plainville, . . .	John Eiden.
7. Cambridge, . .	W. A. Noonan.	30. Revere, . . .	J. E. Lamb.
8. Chelsea, . . .	W. S. Walkley.	31. South Hadley, . .	G. F. Boudreau.
9. Chicopee, . . .	C. L. O'Brien.	32. Somerville, . .	H. E. Bowman.
10. Clinton, . . .	G. L. Chase.	33. Springfield, . .	S. C. Downs.
11. Everett, . . .	E. Clarence Colby.	34. Springfield, . .	Emerson Laboratory.[1]
12. Fall River, . .	H. Boisseau.	35. Taunton, . . .	L. I. Tucker.
13. Fitchburg, . .	J. F. Bresnahan.	36. Wakefield, . . .	H. A. Symonds.
14. Gardner, . . .	C. W. Shippee.	37. Waltham, . . .	A. L. Stone.
15. Greenfield, . .	G. P. Moore.	38. Ware, ...	F. E. Marsh.
16. Haverhill, . . .	H. L. Conner.	39. Watertown, . .	L. C. Simmons.
17. Holyoke, . . .	D. P. Hartnett.	40. Wellesley, . . .	R. W. Hoyt.
18. Lawrence, . . .	J. H. Tobin.	41. Westfield, . . .	W. M. Porter.
19. Lowell, . . .	M. Marster.	42. West Springfield, .	N. T. Smith.
20. Lynn, . . .	H. P. Bennett.	43. Winchendon, . .	G. W. Stanbridge.
21. Millbury, . . .	F. A. Watkins.	44. Winchester, . .	Morris Dinneen.
22. Malden, . . .	J. I. Sanford.	45. Woburn, . . .	E. P. Kelley.
23. Medford, . . .	Winslow Joyce.	46. Worcester, . .	G. L. Berg.

[1] Does work for the State Dairy Bureau.

(*c*) *Water Analysis.*

Ninety-three samples of water have been examined during the past year at the usual charge of $3 a sample. A large number of these, especially those samples taken from wells, have been condemned as unfit for domestic use. Public water supplies are supervised by the State Board of Health.

(*d*) *Milk, Cream and Feeds for Free Examination.*

Many samples of milk, cream and feeding stuffs are received each year at the laboratory for free examination. In general, it is preferred that application be made for sampling and ship-

ping instructions before the sample is submitted. Only samples of direct agricultural interest are considered, and the experiment station will not act in the capacity of a private chemist for a feed manufacturer, milk depot or creamery.

(*e*) *Miscellaneous Work.*

In addition to the work already described, this section has co-operated with other departments of the college and State, as follows: —

1. It has arranged exhibits and furnished speakers in co-operation with the extension service for fairs, farmers' meetings and expositions.
2. It has co-operated with the Bowker Fertilizer Company in making starch determinations on potatoes in connection with the awarding of prizes.
3. It has co-operated with the agricultural department of the college in making analyses of milk in connection with the awarding of prizes at a dairy show held during "farmers' week."
4. It has co-operated with the agricultural department of the experiment station in making analyses of the corn plant to determine the effect of frosts upon the nutritive value of the plant.
5. It has assisted the horticultural department of the college by analyzing root crops to determine the effect of cold storage in modifying their chemical character.

(*f*) *Testing of Pure-bred Cows for Advanced Registry.*

During the year, ten different men have been used for the Holstein-Friesian work, and the entire time of three other men has been taken in conducting the work for the Guernsey, Jersey, Ayrshire and Brown Swiss associations. From Dec. 1, 1912, to Dec. 1, 1913, 86 Guernsey, 122 Jersey, 2 Brown Swiss, 18 Ayrshire and 4 Holstein yearly tests have been completed. There are now on test 110 Jerseys, 111 Guernseys, 24 Ayrshires and 1 Brown Swiss, located at 28 different farms. For the Holstein-Friesian Association there have been completed 120 seven-day tests, 10 thirty-day tests, 5 fourteen-day tests and 1 sixty-day test.

4. Numerical Summary of Substances examined in the Chemical Laboratory.

The following substances have been received and examined: 93 samples of water, 305 milk, 1,452 cream, 3 ice cream, 2 butter, 191 feedstuffs, 149 fertilizers and fertilizer refuse materials, 72 soils, 19 lime products, 22 plant ash and 6 miscellaneous. There have also been examined in connection with experiments in progress by the several departments of the station, 167 samples of milk and cream, 193 cattle feeds and 352 agricultural plants. In connection with the control work, there have been collected 1,299 samples of fertilizer and 1,115 samples of feedstuffs. In addition, 30 samples of coal have been analyzed by the research section for the college heating plant. The total for the year was 5,470. This does not include the work of the research section, where many analyses are made in connection with research problems, nor the work under the dairy law already reported.

5. Correspondence.

The number of letters sent out during the year is about 5,000. The larger part of the correspondence is devoted to work in connection with our several inspection laws. A considerable amount of time, however, is devoted to the answering of special inquiries from the farmers of this State.

REPORT OF THE BOTANIST.

GEO. E. STONE.

During the past year the work in this department has been along the usual lines, attention being given to new problems as they arise. The drought was so severe that an unprecedented number of urgent calls for investigation of diseases had to be attended to, and the diagnosis work taxed our resources severely.

The usual seed work, consisting of separation and tests for germination and purity, has been carried on, but the equipment is deficient, especially for germination work.

Mr. G. H. Chapman, research assistant, has been studying at the University of Prague on leave of absence, and his place has been taken by Mr. O. L. Clark, who has spent three years in German universities and was at one time assistant to Prof. L. Jost of Strassburg University, Elsass.

Many of the lines of investigation which were outlined in our last annual report have been continued, some of them being practically completed and ready for publication. Studies of the diseases of crops and of trees, together with investigations of new methods in tree surgery and of long-distance, high-pressure spraying nozzles especially adapted to shade tree work, have been continued. Some of the nozzles have already proved very satisfactory, and have been reported as cutting the expense of spraying one-half, without any decrease in efficiency. One has been patented in the writer's name and assigned to the college, with the provision that any income derived from its sale shall be used by this department subject to the approval of the committee on experiment department and of the director of the station.

Study has been made of a new bacterial disease of the tomato, and experiments made with extermination of weeds in lawns, etc., and tests of various proprietary sprays and fungicides and of crude by-products recommended as soil fungicides and sprays, some of which have proved very efficient in controlling the potato scab. (See twenty-fifth annual report.)

Experiments relating to the exclusion of roots from drain tile have been continued, and positive results obtained. Experiments with chemical methods to destroy horsetail (*Equisetum*), one of the worst weeds in cranberry bogs, also give promise of being successful. Attention has been given to the influence of soil moisture on seed germination, and some problems relating to the stimulating effects on crops of various gases have been taken up. Further study is being made of soil sterilization, particularly of new methods; and also of malnutrition of plants.

A number of problems properly coming under the Adams fund project, and covering in a broad way the effects of meteorological conditions on plants, are being studied as follows: the relation of light to burning from spraying with fungicides and insecticides; relation of light to burning from miscible oils; nature and cause of burning by fumigation with various gases; effects of electricity on nitrogen fixation in soils and on the stimulation of plants in general.

Some of these investigations have been published during the past year in Bulletin No. 144, "The Relation of Light to Greenhouse Culture," a physiological and pathological study of the subject; another paper dealing with the relation of light to burning from miscible oils is in preparation; and still others on research problems which have been studied for some time in our laboratory.

REPORT OF THE ENTOMOLOGIST.

H. T. FERNALD.

The entomological work of the experiment station during 1913 has been mainly along lines indicated in previous reports. It has not seemed wise to take up many new subjects for investigation, but, instead, to devote most of the time available to those already under way.

Experiments for the control of the onion maggot, begun in 1912, were discussed in the last annual report. The work of the first season indicated that the methods recommended by most writers were either ineffective or too costly for practical use. The season of 1913 was therefore devoted to the testing of new materials as insecticides, particularly applied during the planting process, in order to avoid the expense of special applications. None of the materials thus tested proved to be entirely satisfactory, though one or two were sufficiently so to warrant repetition the coming year, when further experiments will accordingly be made.

Studies on the marguerite leaf miner (*Phytomyza chrysanthemi* Kow.) have been made at intervals at this station for a number of years, as opportunity offered. The work has at last been completed, the entire life history of this greenhouse pest having been worked out, together with methods for its control, and the completed paper by Mr. M. T. Smulyan is about ready for publication.

Observations of the dates of hatching of the more important scale insects of this region have been continued, and the data which have been accumulating on this subject should prove of much value, at least locally. The work should be continued at least two or three years longer.

The box leaf miner (*Monarthropalpus buxi* Lab.), a recent arrival in this country, has caused much injury to box trees and hedges. Its life history and habits are little understood, and a study of this subject and of control methods has been begun.

Tests of various insecticides have been made from time to time, though in most cases sufficient opportunity was not available for anything like sufficient experiments to permit final conclusions. Of the materials tested, the dry arsenate of lead manufactured by the Corona Chemical Company proved very satisfactory, as did also Bowker's lime sulfur prepared by the Bowker Chemical Company, and lead arsenate paste furnished by the Powers, Weightman, Rosengarten Company. Kylscale and soluble sulfur did not give as satisfactory results in controlling the San José scale as had been hoped, though many of the insects were undoubtedly destroyed.

Under the Adams fund, work has been continued on the projects already authorized. In the study of the importance of wasps as parasites it had already been found that any determination of this for the different kinds must necessitate a recognition of the different species, of their distribution and relative abundance. To clear up these points, a study of the material from this country in Europe was necessary, and fortunately this became possible last year. The way is now clear to continue this work on a sound basis as a result of these studies, and it is being prosecuted as rapidly as possible.

The tests of various insecticides, referred to in previous reports, have been continued, and about 4,000 are now recorded. The results thus far have been as satisfactory as could be expected, and the project will be continued.

The work of the apiarist of the station is stated as follows: —

As reported in person to Dr. Evans, Sept. 29, 1913, the Adams fund project of the apiarist of the station has progressed along its originally intended lines. Effort was made to ascertain the number of visits per unit of time which are made by a bee to flowers, as, for instance, to the clover. The visits are a complex of reactions, which thus far are interpreted with consideration of weather, abundance of nectar in the flowers, the frequency of visits of other bees to the same flower,

the time of day, and nectar-yielding conditions. Earlier experiments with bees in reaction to tissue paper flowers evinced that either touch or odor was a factor as well as color. Here again odor apparently was involved in the case of clover. Apart from the jurisdiction of the college, it was reported that significant findings had been made concerning dissemination, persistency, and especially the incipient stages of the brood diseases of bees, respectively European foul brood, American foul brood and sac brood. Observations were also made concerning the curative value of the so-called "dequeening process," and the importance of Italianization. Equipment has been procured for an experiment the current month concerning stimuli which attract bees.

The discovery of an active and very efficient parasite of the San José scale was made at this station during the year, and deserves somewhat more than casual mention.

Numerous specimens of this scale are examined each year. Generally only a few parasites have been noted, these being the well-known *Aphelinus fuscipennis* How., and not sufficiently abundant to be of any importance. In the fall of 1912, however, a large amount of parasitism was observed, and the parasites were accordingly bred. They proved to be an unknown species which is described and published in the Annals of the Entomological Society of America for March, 1913, by Mr. D. G. Tower, a graduate student at the college, in whose hands this subject had been placed to follow up. During the year Mr. Tower has continued his observations on this insect and has its life history nearly completed.

During 1913 this parasite has been extremely abundant, and in many cases has parasitized over 90 per cent. of the scales on the branches of the plants examined. It has also been found in other parts of the State, and has been reported from Connecticut, New York and Pennsylvania, and is probably still more widely distributed. The station has sent out supplies of parasitized scales to a number of other States and is still supplying material on request.

That this insect may be of great value is evident by its work. It is only fair, however, to call attention to the fact that such insects often appear in great abundance for a time, after which they become less numerous and accordingly far less important. In any case, so long as a single San José scale can give rise to

over three billions of descendants in a single year (Bulletin 4, Division of Entomology, United States Department of Agriculture) it can hardly be anticipated that spraying for this insect can be omitted.

The correspondence during the year has been fully as large as heretofore, and many insects sent in have been species of which little is known. This has necessitated a large amount of research, and often the rearing of the insects before satisfactory information as to methods of control could be furnished.

Insects found by the nursery inspectors of the State on imported nursery stock are sent to this station for identification, and this phase of the work, being quite novel, has also taken considerable time. A number of foreign pests not at present established in this country have been discovered in this way.

The collections have constantly increased in size and value. There are now probably considerably over 100,000 pinned specimens, besides many samples of work done by insects, a large number of mounted slides and many alcoholic specimens. The proper care of a collection of this size, and of adding to it material collected each year, is sufficient to occupy the entire time of one man. At present it is partially attended to as opportunity offers. The time is rapidly approaching when it must receive more attention or greatly lose in value.

REPORT OF THE POULTRY HUSBANDMAN.

JOHN C. GRAHAM.

The chief investigations started last year, and which are still in progress, consist of a thorough study of the capacity of each hen to produce (*a*) eggs, (*b*) fertile eggs, (*c*) hatchable eggs, (*d*) viable chicks, (*e*) vigorous adults, and of the ability of each bird to transmit these qualities to its progeny.

Secondary studies are being made of the inheritance of various color and form characteristics. To this end, 144 pullets were trapnested through the year 1913.

During the breeding season eggs were incubated, a record being kept of each egg and its fate, and over 2,000 chicks were hatched, as many as possible being reared to maturity.

Feather charts of all adults have been made. Besides the main experiments, various trials have been made, from time to time, of such problems as suggest themselves with a view of testing their possibilities. Considerable time has been spent on autopsies of birds sent in by poultrymen.

During the last half of the hatching season it was found that coccidiotis had gained such headway that a large number of chicks were lost from this disease, besides injuring many more. There are so many obscure points in the life history of the causative organism that a large amount of time has to be devoted to its study, to the disadvantage of our other investigations; however, certain points regarding the disease had to be made out before we could proceed with our other work with confidence. These points have now been studied with sufficient care to outline a favorable method of management.

VETERINARY DEPARTMENT.

ON THE DIAGNOSIS OF INFECTION WITH BACTERIUM PULLORUM IN THE DOMESTIC FOWL.

By GEO. EDWARD GAGE

WITH THE ASSISTANCE OF

BERYL H. PAIGE AND HAROLD W. HYLAND

(*From the Department of Veterinary Science*)

MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION.

During the last two years the scientific evidence at hand concerning the rôle of *Bacterium pullorum* (Rettger) in bacillary white diarrhœa of young chicks and relations of it to ovarian infection in adult fowls has been most conclusive. Rettger and Stoneburn[1] pointed out the fact that adult hens were the original source of infection to young chicks suffering with bacillary white diarrhœa.

In their report of 1911[2] they further substantiate the results of the previous paper in that adult hens are the original source of infection; that eggs from infected hens may contain the organism in the yolk.

In a third report, 1912,[3] they fully support statements of their previous work concerning ovarian infection, and they conclude that the ovaries may become infected by contact of the hens with infected hens or by artificial infection of the litter. "The infection is, in all probability, acquired through the mouth."

Gage, in 1910–11,[4] in publication of reports from experiments conducted at the Maryland Experiment Station, concluded that Rettger and Stoneburn were correct in their work of the previous year, corroborating the fact that white diarrhœa, as poultrymen understand it, is a bacillary disease caused by *Bacterium pullorum* (R), and that the hen is the original

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[1] Rettger, L. F., and Stoneburn, F. H.: Bulletin No. 60, 1909, Storrs Agricultural Experiment Station. "Bacillary white diarrhœa of young chicks."

[2] Rettger, L. F., and Stoneburn, F. H., Bulletin No. 68, 1911, Storrs Agricultural Experiment Station. "Bacillary white diarrhœa of young chicks" (second report).

[3] Rettger, L. F., Stoneburn, F. H., and Kirkpatrick, Wm. F.: Bulletin No. 74, 1912. "Bacillary white diarrhœa of young chicks" (third report).

[4] Gage, Geo. Edward: "Notes on ovarian infection with *Bacterium pullorum* (Rettger) in the domestic fowl." Journal Medical Research, Vol. XXIV., No. ; N. S., Vol. XIX., No. 3; June, 1911, pp. 491–496.

source of infection, transmitting the organism from the ovary to the eggs.

Jones, in his reports of 1910[1] and 1911,[2] again supports the work of Rettger and Stoneburn, and also finds that the local disease in the ovary of adult fowls may be produced by the intravenous injections of *Bacterium pullorum.*

From these reports it can be seen that the problem now consists in methods of determining the presence of the virus in adult hens. From examination of eggs it has been almost impossible to make a diagnosis of this infection within a short time, since *Bacterium pullorum* is eliminated so irregularly that it is necessary, often, to examine all eggs laid by a suspected hen over a long period.

Jones [3] suggested the use of an agglutination similar to that used in the diagnosis of glanders and contagious abortion for detecting ovarian infection, and in a later paper [4] has given an excellent example of the value of the macroscopic agglutination test for detecting individuals harboring *B. pullorum.*

It is the object of this paper to present the results of the work conducted in the investigational laboratory of the department of veterinary science concerning the diagnosis of this ovarian infection in adult hens by egg analysis and by macroscopic agglutination tests, together with data which have been obtained concerning the various factors which must be considered in making the tests. It shall also serve to demonstrate the practicability of these tests as a routine laboratory procedure, the work having been performed in many respects by three different technicians.

The subjects used for these experiments were all suspected of harboring the virus of *Bacterium pullorum.* The organism had been detected in the yolk of eggs from hens Nos. 267, 792, 452, 714 and 464 prior to their arrival at the laboratory. Hens Nos. 1, 2, 4, 5, 6, 7, 8, 10, 13, 18, 22, 34, 35, 46, 48, 49, 52, 53, 60, 61, 77, 312, 315, 618 and 2096 were all suspects. Hens Nos. 1, 2, 4, 5, 6, 7, 8, 10, 13, 18, 22, 48, 52 and 53 had been inoculated intravenously with 1 c.c. of a bouillon suspension of a culture of *Bacterium pullorum*[5] known according to the filing-denotation of *Bacterium pullorum* in this laboratory as M., which had been isolated from the ovaries of a white Orpington pullet, and proven absolutely to be capable of producing the disease in young chicks. Hens Nos. 34, 35, 46, 49, 60, 61, 77, 312, 315, 618 and 2096 had been closely associated with hens which had received the intravenous injection, but, so far as the author has been able to ascertain, only for a short time. Since the data on these last

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[1] Jones, F. S.: "Fatal septecemia or bacillary white diarrhœa in young chickens." Annual Report of the New York State Veterinary College for 1910, pp. 111–129.

[2] Jones, F. S.: "Further studies on bacillary white diarrhœa in young chickens." Report, New York State Veterinary College, 1910–11, pp. 69–88.

[3] Jones, F. S.: Report, New York State Veterinary College for 1910–11, p. 76.

[4] Jones, F. S.: "The value of the macroscopic agglutination test in detecting fowls that are harboring *Bact. pullorum.*" Journal Medical Research, Vol. XXVII., No. 4; N. S., Vol. XXII., No. 4, pp. 485–495.

[5] Gage: "Notes on ovarian infection with *Bacterium pullorum* in the domestic fowl." Journal Medical Research, Vol. XXIV., No. 5; N. S., Vol. XIX., No. 3, p. 493.

birds were so incomplete concerning their histories, it was considered wise to put all together and include them all in the tests. Birds Nos. 1, 2, 4, 5, 6, 7, 8, 10, 13, 18, 22, 48, 52 and 53 were all more than three years old, and were sent to this laboratory through the kindness of Director H. J. Patterson of the Maryland Agricultural Experiment Station, where the author had started work to determine the possibility of artificial infection of ovarian tissue by intravenous injections of the organisms, — work which was interrupted before final results could be obtained.[1] Jones,[2] however, was successful in his attempts to bring about ovarian infection with *Bact. pullorum* by the injection of pure cultures of the organism into the blood circulation of hens.

All individuals retained for these tests were trap-nested and complete egg records kept of each hen.

Methods employed in the Examination of Eggs for Bacterium Pullorum.

The object primarily in making the examination of all eggs laid by these suspected hens was to determine if possible the presence of the organism in the yolk, which would be of value in checking up the work in connection with any of the serum reactions which later might prove positive. The method used for these egg analyses was essentially that used by Rettger.[3] Eggs were allowed to remain several minutes in carbolic acid (1–40) and dried with sterile absorbent cotton. The end of the egg was sterilized by flaming, the flamed portion cut around with sterile scissors. The albumin was carefully separated from the yolk and the yolk inserted into a large test tube (Buchner type) containing about 30 c.c. sterile bouillon. In the first part of the egg-testing work fresh eggs were studied, but later the eggs were incubated prior to the testing, and in some instances sufficiently long for embryos to develop. In such cases a sterile platinum loop or scissors were used to aid in freeing the embryo from the shell and albumin. If embryo was very large it was inserted into sterile bouillon along with the rest of the yolk. The disintegrated egg yolks in bouillon were placed in the incubator at 38° C. and allowed to remain there for varying lengths of time, the shortest period being twenty-four hours and the longest two hundred and eighty hours. After tubes were taken from bacteriological incubator the material was thoroughly mixed and four samples streaked on four different tubes of agar. These were placed in the bacteriological incubator and examined macroscopically for the presence of the typical *Bact. pullorum* colonies at the end of twenty-four, forty-eight and seventy-two hours. A tube was not considered negative until it had been allowed to incubate for

[1] Work referred to by Dr. Rettger in Bulletin No. 74, Storrs Agricultural Experiment Station Storrs, Conn., p. 162, line 12.

[2] Jones, F. S., "Further studies on bacillary white diarrhœa in young chickens." Report, New York State Veterinary College, 1910–11, pp. 69–88.

[3] Rettger, L. F., and Stoneburn, F. H., Bulletin No. 68, 1911, Storrs Agricultural Experiment Station, "Bacillary white diarrhœa of young chicks" (second report).

seventy-two hours. In many cases when there was doubt concerning organism, all materials were plated out and colony again streaked from such plates.

In view of the fact that many inquiries had been received here at this laboratory concerning the egg test for the determination of this organism, it was decided worth while to test all eggs laid by these suspected hens, and also to record what effect the retention of egg prior to testing, and length of time egg material remained in the bacteriological incubator at 38° to 39° C., had in facilitating isolation of the organism.

In tables 1, 2 and 3 are exhibited the data obtained from the egg tests tabulated to show when egg was laid, by which hen laid, and whether the organism was isolated from the hen, a fact designated by a plus sign. It also shows to how long a period of incubation the egg material in bouillon was submitted before being streaked on the agar slants.

During the period of making the first egg tests all eggs were retained at room temperature until tested, or they were tested on the same day, soon after laying. Later, however, it was found advisable to retain at the temperature of the bacteriological incubator, about 39° C., before inserting in sterile bouillon, to afford perhaps a preliminary proliferation of the organism.

TABLE 1.

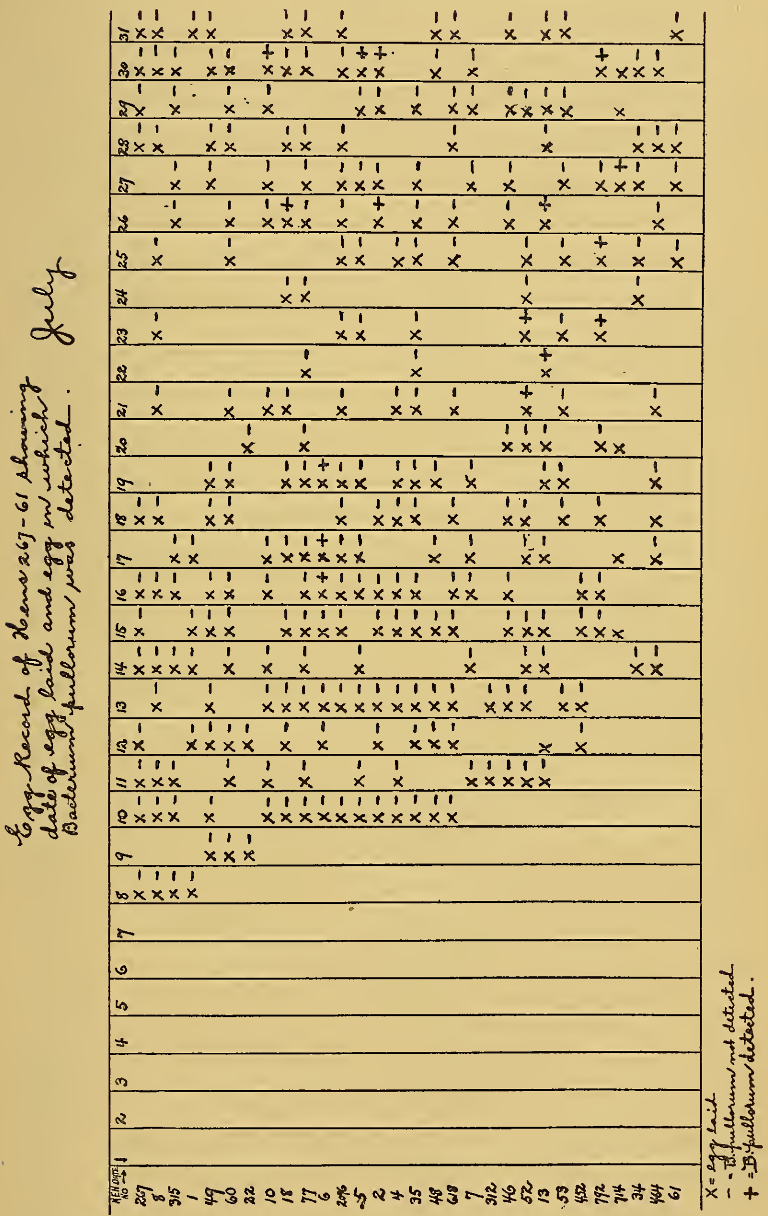
Egg Record of Hens 267-61 showing date of egg laid and egg in which Bacterium pullorum was detected. July
X = egg laid
– = B. pullorum not detected
+ = B. pullorum detected

TABLE 2.

Egg Record of Hens 267–61 showing date of egg laid and egg in which Bacterium pullorum was detected. August

Hen No. / Date →	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
267	X –	X –		X –	X –		X –						X –		X –	X –	X –		X –		X –	X –	X –	X –			X –				
8		X –		X –		X –		X –				X –		X –		X –		X +							X –			X –		X –	
315	X –	X –		X –	X –		X –	X –				X –		X –		X –	X –		X –	X –		X –		X –		X –		X –		X –	X –
1	X –		X –	X –				X –		X –		X –			X +																
49	X –		X –	X –		X –	X –		X –	X –		X –	X –		X –	X –	X –		X –	X –		X –		X –	X –		X –				X
60	X –		X –													X –	X –		X –	X –		X –									
22													X –	X –		X –	X –		X –	X –		X –				X –					
10	X –	X –		X –		X –				X –		X +		X –	X +		X –														
18						X –					X –		X –			X –	X –				X –		X –		X –						
77	X –	X –		X –	X –	X –	X –	X –	X –		X –	X –	X –	X –		X –	X –	X –	X –		X –		X –	X –			X –			X –	
6			X –								DIED																				
20½		X –	X –		X –		X –				X –	X +	X –	X –		X –	X –	X –	X –		X –	X –	X –		X –						
5	X –	X +		X +	X –		X –	X –	DIED																						
2	X –	X –																													
4							X –		X –		X –	X –		X –	X –		X –			X –				X –				X –			X –
35	X –		X –		X –	X –				X –	X –	X –		X –	X –		X –				X –				X –						X –
48		X –	X –		X –			X –			X –								X –		X –		X –		X –						
618	X –	X –		X –	X –		X –	X –	X –		X –	X –		X –	X –	X –		X –	X –	X –		X –		X –							
7	X –		X –	X +		X –		X –			X –		X +		X –		X –		X –		X –										
46	X –			X –		X –	X –	X –		X –	X –	X –		X –	X –																
13		X –	X –		X –	X –		X –	X –				X –		X –	X –		X –		X –					X +						
53	X	–			X –	X –			X –	X –		X –	X –		X –	X –		X –		X –											
792	X –	X –			X –	–			X –		X –	X +		X –	X –		X –	X –		X –	X –		X –	X –		X –		X –		X –	
714	X –	X –		X –		X –	X –		X –		X –		X +		X –		X –									X –		X –		X –	
34	X –		X –		X –								X –	X –		X –	X –	X –		X –		X –		X –							
464						X –					X –																				
61	X –	X –		X –	X –				X –		X –	X –		X –	X –	X –		X –										X –		X –	X –

X = egg laid

– = B. pullorum not detected

+ = B. pullorum detected

TABLE 3.

Egg Record of Hens 267–61 showing date of egg laid and egg in which Bacterium pullorum was detected September

HEN NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
267																			X –	X –	X –				X –		X –				
8																															
315		X –		X –		X –				X –		X –		X –			X –			X –	X –										
1																															
49		X –		X –	X –																–										
60	X –		X –	X –																		X –			X –						
22																															
10																															
18																															
77																															
6																															
2096									X –	X –		X –						X –		X –											
5																															
2																															
4				X –	X –				X –	X –		X –				X –					X –		X –								
35		X –																													
48				X –		X +																									
618																															
7																															
312																															
46																															
52																															
13																															
53																									X –						
452																															
792	X –																														
714	X –																				X +										
34								X –																							
464											X –		X +			X +															
61																		X –													

X = egg laid
– = B. pullorum not detected
+ = B. pullorum detected

From Table 4, it can be seen that of the 619 eggs tested *Bacterium pullorum* was detected in eggs laid by hen No. 10, once during July, egg laid 7–30–13; by hen No. 18, once during July, egg laid 7–26–13; by hen No. 6, three times during the month, eggs laid 7–16–13, 7–17–13 and 7–19–13; by hen No. 5, once during month, egg laid 7–30–13; by hen No. 2, twice during month, eggs laid 7–26–13 and 7–30–13; by hen No. 52, twice during month, eggs laid 7–21–13 and 7–23–13; by hen No. 13, twice, eggs laid 7–22–13 and 7–26–13; by hen No. 792, three times, eggs laid 7–23–13, 7–25–13 and 7–30–13; by hen No. 714, once during month, egg laid 7–27–13. During August from hen No. 8 *Bact. pullorum* was isolated from one egg laid 8–18–13; by hen No. 1, once during month, egg laid 8–15–13; by hen No. 10, twice, eggs laid 8–12–13 and 8–15–13; by hen No. 2096, once during month, egg laid 8–12–13; by hen No. 5, twice, eggs laid 8–2–13 and 8–4–13; by hen No. 7, twice, eggs laid 8–4–13 and 8–13–13; by hen No. 13, once, egg laid 8–25–13; by hen No. 792, once, egg laid 8–12–13; by hen No. 714, once, egg laid 8–13–13. During September the organism was isolated from egg of hen No. 48, once, egg laid 9–6–13; by hen No. 714, once, egg laid 9–21–13; by hen No. 464, twice, eggs laid 9–13–13 and 9–16–13.

Of the 16 cultures of *Bacterium pullorum* isolated from eggs in July the yolk material of 13 in sterile bouillon had been retained in bacteriological incubator for more than seventy-two hours. Of the 12 isolated in August, all yolk material in bouillon had been retained in bacteriological incubator more than seventy-two hours. From the 4 isolated in September, the egg material had been in incubator but forty-eight hours. After August 1 it was planned to put all eggs in bacteriological incubator prior to testing, and this brought forth egg material which yielded cultures of *Bacterium pullorum* which had not been detected in July, namely, the infection was detected in hen No. 8, hen No. 1, hen No. 2096 and hen No. 7. By the previous incubation of eggs, for one to three days, the organism had multiplied to such an extent that it was possible to detect the organisms in 7 individuals in whom it had not been detected in July. From egg material incubated in bacteriological incubator at 38° to 39° C. for seventy-two hours or longer it was much easier to detect the organism. Usually it was present in large numbers, and the organism on the agar-slant usually became visible within the first twenty-four hours' incubation. In general it may be stated that egg testing of these hens' eggs yielded better results after this preliminary incubation of the eggs in bacteriological incubator, and it was found always advisable to wait seventy-two hours before considering a sample negative as regards colonies on subsequent agar streaks.

From what has been determined here, and from the work of Rettger and Jones, it can be clearly seen that diagnosis by egg testing is impractical. In some cases, however, the egg testing has given results with the examination of the first few eggs. According to the work in this laboratory, it has been found that if a bird is badly infected persistence in egg testing will usually yield a positive result. Of the 619 eggs tested from hens in

TABLE 4.

TABLE SHOWING WHEN EGG WAS LAID, HEN NUMBER, NUMBER OF HOURS MATERIAL WAS RETAINED IN BACTERIOLOGICAL INCUBATOR

+ = ORGANISM FOUND
− = ORGANISM NOT FOUND

JULY	24 HRS	43 HRS	48 HRS	65 HRS	72 HRS	88 HRS	90 HRS	97 HRS	110 HRS	120 HRS	136 HRS	140 HRS	163 HRS	168 HRS	190 HRS	210 HRS	256 HRS	263 HRS	283 HRS
	6 7/16 +	22 7/20 −	267 7/8 −	267 7/12 −	267 7/10 −	267 7/18 −	267 7/6 −	8 7/28 −	315 7/26 −	8 7/21 −	267 7/30 −	1 8/3 −	60 7/19 −	267 7/28 −	8 7/25 −	267 7/31 −	61 7/28 −	49 8/22 −	618 7/28 −
	35 7/2 −		267 7/11 −	8 7/13 −	8 7/8 −	8 7/8 −	267 7/29 −	49 7/27 −	315 7/27 −	8 7/23 −	315 7/30 −	49 8/3 −	35 7/29 −		60 7/25 −	8 7/31 −			13 7/28 −
			267 7/14 −	8 7/14 −	8 7/10 −	315 7/7 −	315 7/6 −	49 7/28 −	60 7/26 −	60 7/21 −	49 7/30 −	60 8/3 −	48 7/30 −		10 7/26 −	1 7/31 −			
			267 7/15 −	1 7/8 −	315 7/10 −	1 7/7 −	315 7/29 −	10 7/27 −	77 7/26 −	10 7/21 −	60 7/28 −	35 8/3 −	46 7/31 −		18 7/26 +	49 7/31 −			
			8 7/11 −	1 7/12 −	315 7/11 −	49 7/18 −	18 7/5 −	18 7/28 −	77 7/27 −	18 7/21 −	60 7/29 −	7 8/3 −	53 7/19 −		2096 7/25 −	10 7/30 +			
			8 7/16 −	60 7/12 −	49 7/9 −	60 7/18 −	5 7/6 −	2 7/29 −	77 7/28 −	77 7/20 −	60 7/30 −	61 8/4 −	53 7/29 −		5 7/25 −	18 7/31 −			
			8 7/30 −	22 7/12 −	49 7/19 −	10 7/7 −	35 7/6 −	618 7/29 −	2096 7/26 −	77 7/22 −	10 7/29 −		AUGUST		4 7/25 −	77 7/31 −			
			315 7/8 −	18 7/12 −	60 7/9 −	18 7/7 −	618 7/6 −	46 7/27 −	2096 7/27 −	77 7/24 −	18 7/30 −		267 8/1 −		35 7/25 −	2096 7/31 −			
			315 7/14 −	77 7/13 −	22 7/9 −	77 7/7 −	7 7/6 −	34 7/27 −	5 7/27 −	2096 7/21 −	2096 7/28 −		8 8/2 −		618 7/25 −	5 7/29 −			
			1 7/14 −	77 7/15 −	10 7/10 −	77 7/19 −	46 7/6 −	464 7/28 −	2 7/26 +	2096 7/23 −	2096 7/30 −		315 8/24 −		52 7/25 −	48 7/31 −			
			1 7/15 −	6 7/12 −	10 7/11 −	6 7/17 +	13 7/5 −	AUGUST	2 7/26 −	5 7/23 −	5 7/30 +		315 8/26 −		53 7/25 −	618 7/31 −			
			49 7/13 −	2096 7/13 −	18 7/10 −	6 7/19 +	452 7/6 −	315 8/7 −	35 7/26 −	4 7/21 −	2 7/30 +		315 8/28 −		792 7/25 +	52 7/29 −			
			49 7/15 −	5 7/13 −	18 7/19 −	2096 7/18 −	714 7/7 −	2096 8/7 −	35 7/27 −	35 7/21 −	7 7/29 −		315 8/30 −		61 7/25 −	13 7/31 −			
			49 7/16 −	2 7/12 −	77 7/10 −	5 7/7 −	AUGUST	618 8/7 −	618 7/26 −	35 7/22 −	7 7/30 −		315 8/31 −			53 7/31 −			
			60 7/11 −	4 7/12 −	6 7/10 −	2 7/18 −	267 8/5 −	618 8/15 −	7 7/27 −	35 7/23 −	46 7/29 −		49 8/1 −			34 7/28 −			
			60 7/14 −	4 7/13 −	2096 7/10 −	4 7/18 −	267 8/7 −	618 8/16 −	46 7/26 −	618 7/21 −	792 7/30 +		49 8/24 −			61 7/31 −			
			60 7/15 −	35 7/12 −	2096 7/19 −	4 7/19 −	267 8/24 −	7 8/15 −	13 7/26 +	46 7/20 −	714 7/30 −		49 8/25 −			AUGUST			
			60 7/16 −	35 7/13 −	5 7/10 −	35 7/18 −	267 8/27 −	7 8/17 −	53 7/27 −	52 7/21 +	34 7/30 −		49 8/27 −			267 8/2 −			
			10 7/13 −	35 7/15 −	5 7/19 −	35 7/19 −	8 8/6 −	714 8/7 −	792 7/27 −	52 7/23 +	464 7/30 −		49 8/31 −			315 8/1 −			
			10 7/14 −	48 7/12 −	2 7/10 −	48 7/17 −	8 8/8 −		714 7/27 +	52 7/24 −	AUGUST		22 8/26 −			315 8/2 −			
			10 7/16 −	48 7/13 −	4 7/10 −	618 7/19 −	8 8/25 −	315 9/2 −	714 7/29 −	13 7/18 −	5 8/1 −		18 8/25 −			1 8/1 −			
			18 7/13 −	618 7/12 −	4 7/10 −	7 7/7 −	8 8/28 −	315 9/4 −	464 7/26 −	13 7/19 −	46 8/1 −		77 8/24 −			60 8/1 −			
			77 7/14 −	7 7/14 −	35 7/10 −	46 7/18 −	8 8/30 −	49 9/2 −	61 7/27 −	13 7/20 −	792 8/1 −		77 8/27 −			10 8/1 −			
			77 7/16 −	46 7/15 −	48 7/10 −	52 7/18 −	315 8/8 −	49 9/4 −	AUGUST	13 7/22 +			77 8/30 −			10 8/2 −			
			77 7/30 −	52 7/13 −	48 7/19 −	53 7/18 −	315 8/2 −	49 9/5 −	267 8/15 −	53 7/21 −			2096 8/25 −			77 8/1 −			
			6 7/13 −	52 7/15 −	618 7/10 −	792 7/18 −	1 8/8 −	60 9/1 −	8 8/14 −	53 7/23 −			4 8/24 −			77 8/2 −			
			6 7/15 −	13 7/12 −	53 7/13 −	464 7/7 −	1 8/10 −	60 9/3 −	8 8/18 +	792 7/23 +			4 8/28 −			2096 8/2 −			
			2096 7/5 −	452 7/12 −	792 7/20 −	464 7/9 −	49 8/6 −	60 9/4 −	315 8/14 −	714 7/20 −			4 8/31 −			5 8/2 +			
			2096 7/6 −	792 7/15 −	AUGUST	AUGUST	49 8/7 −	4 9/4 −	49 8/13 −	34 7/24 −			35 8/25 −			2 8/1 −			
			2096 7/7 −	464 7/16 −	315 8/5 −	267 8/3 −	49 8/9 −	4 9/5 −	49 8/15 −	34 7/25 −			35 8/31 −			2 8/2 −			
			5 7/11 −		5 8/7 −	267 8/16 −	49 8/10 −	35 9/2 −	22 8/13 −	464 7/21 −			48 8/25 −			35 8/1 −			
			5 7/14 −		4 8/11 −	267 8/7 −	49 8/12 −	48 9/4 −	22 8/14 −	AUGUST			618 8/24 −			48 8/2 −			
			2 7/13 −		7 8/11 −	8 8/12 −	10 8/6 −	792 9/1 −	10 8/14 −	267 8/4 −			7 8/1 −			618 8/1 −			
			2 7/15 −		61 8/9 −	8 8/16 −	10 8/10 −	714 9/1 −	18 8/13 −	267 8/19 −			13 8/25 +			618 8/2 −			
			2 7/16 −			315 8/16 −	10 8/2 +		77 8/13 −	267 8/21 −			792 8/26 −			13 8/2 −			
			4 7/15 −			1 8/2 −	18 8/11 −		77 8/14 −	267 8/22 −			792 8/28 −			53 8/2 −			
			4 7/16 −			1 8/15 +	77 8/6 −		77 8/18 −	267 8/23 −			792 8/30 −			792 8/2 −			
			48 7/15 −			49 8/16 −	77 8/7 −		2096 8/18 −	8 8/4 −			714 8/26 −			714 8/1 −			
			618 7/13 −			49 8/7 −	77 8/8 −		4 8/14 −	315 8/4 −			714 8/28 −			714 8/2 −			
			618 7/15 −			60 8/16 −	77 8/9 −		35 8/14 −	315 8/19 −			714 8/30 −			61 8/2 −			
			7 7/11 −			60 8/7 −	77 8/11 −		35 8/17 −	315 8/20 −			34 8/1 −						
			312 7/11 −			22 8/16 −	77 8/12 −		618 8/14 −	315 8/22 −			34 8/24 −						
			312 7/13 −			22 8/7 −	2096 8/5 −		618 8/19 −	1 8/4 −			61 8/1 −						
			46 7/11 −			10 8/15 +	2096 8/11 −		7 8/13 +	49 8/4 −			61 8/28 −						
			46 7/13 −			10 8/7 −	2096 8/12 +		46 8/14 −	49 8/19 −			61 8/30 −						
			52 7/11 −			18 8/16 −	2096 8/3 −		53 8/8 −	49 8/20 −			61 8/31 −						
			52 7/14 −			18 8/7 −	2096 8/6 −		792 8/14 −	60 8/19 −									
			52 7/7 −			77 8/14 −	2096 8/7 −		34 8/14 −	60 8/20 −									
			13 7/11 −			77 8/16 −	5 8/5 −		34 8/18 −	60 8/22 −									
			13 7/14 −			618 8/8 −	5 8/8 −		61 8/14 −	22 8/19 −									
			13 7/17 −			13 8/15 −	4 8/7 −		61 8/15 −	22 8/20 −									
			452 7/13 −			13 8/16 −	4 8/9 −			22 8/22 −									
			452 7/15 −			13 8/8 −	4 8/2 −			10 8/4 −									
			792 7/16 −			53 8/5 −	4 8/5 −			18 8/6 −									
			714 7/15 −			53 8/16 −	4 8/7 −			18 8/21 −									
			34 7/14 −			792 8/15 −	35 8/5 −			18 8/23 −									
			SEPTEMBER			34 8/16 −	35 8/6 −			77 8/4 −									
			267 9/19 −			34 8/7 −	35 8/10 −			77 8/5 −									
			267 9/20 −			61 8/6 −	35 8/11 −			77 8/19 −									
			267 9/21 −			61 8/8 −	35 8/5 −			77 8/21 −									
			267 9/25 −				48 8/5 −			77 8/23 −									
			267 9/27 −				48 8/8 −			6 8/3 −									
			315 9/6 −				48 8/11 −			2096 8/3 −									
			315 9/10 −				618 8/5 −			2096 8/19 −									
			315 9/12 −				618 8/8 −			2096 8/21 −									
			315 9/14 −				618 8/9 −			2096 8/22 −									
			315 9/17 −				618 8/11 −			2096 8/23 −									
			315 9/20 −				618 8/12 −			5 8/4 +									
			315 9/21 −				7 8/6 −			4 8/20 −									
			60 9/22 −				7 8/8 −			35 8/21 −									
			60 9/25 −				46 8/6 −			48 8/3 −									
			2096 9/9 −				46 8/8 −			48 8/19 −									
			2096 9/10 −				46 8/10 −			48 8/21 −									
			2096 9/12 −				46 8/11 −			48 8/23 −									
			2096 9/18 −				46 8/12 −			618 8/4 −									
			2096 9/20 −				46 8/15 −			618 8/20 −									
			4 9/9 −				13 8/6 −			618 8/22 −									
			4 9/10 −				13 8/8 −			7 8/4 +									
			4 9/12 −				13 8/9 −			7 8/19 −									
			4 9/16 −				13 8/13 −			7 8/21 −									
			4 9/21 −				53 8/6 −			46 8/4 −									
			4 9/23 −				53 8/9 −			46 8/7 −									
			48 9/16 +				53 8/10 −			13 8/3 −									
			53 9/25 −				53 8/12 −			13 8/5 −									
			714 9/21 +				53 8/13 −			13 8/20 −									
			34 9/8 −				792 8/9 −			53 8/5 −									
			464 9/11 −				792 8/11 −			53 8/20 −									
			464 9/13 +				792 8/12 +			792 8/5 −									
			464 9/16 +				792 8/7 −			792 8/20 −									
			61 9/18 −				792 8/8 −			792 8/21 −									
							714 8/6 −			792 8/23 −									
							714 8/9 −			792 8/24 −									
							714 8/11 −			714 8/4 −									
							714 8/13 +			34 8/3 −									
							714 8/15 −			34 8/20 −									
							714 8/17 −			34 8/22 −									
							34 8/5 −												
							34 8/13 −												
							464 8/6 −												
							464 8/11 −												
							61 8/5 −												
							61 8/11 −												
							61 8/12 −												

this experiment during July, August and the first part of September 32 were found to contain the organism, detected in hens Nos. 10, 18, 6, 5, 2, 52, 13, 792, 8, 1, 2096, 7, 714, 267, 48 and 464. With hen No. 10, 11 eggs were tested, covering a laying period of seventeen days, before the organism was detected. With hen No. 18, 8 eggs were tested, covering a laying period of sixteen days prior to its detection. With hen No. 6, 5 eggs were tested, covering a laying period of six days. With hen No. 5, 12 eggs were tested, covering a laying period of twenty days. With the other 11 infected birds it varied from the 6th to the 21st egg laid before *Bacterium pullorum* was detected for the first time, and the laying periods varied from eight to sixty-one days (see Table 5 on page 10).

It is interesting to note at this point that all the hens, except 22, which were received from the Maryland Experiment Station, previously inoculated intravenously with a pure culture of *Bacterium pullorum*, after two years, showed positively the ovarian infection. This is in full agreement with the work of Dr. Jones, — that it is possible to cause local infection and cause such infection through the blood system.

As stated before, it has not been the primary object of these egg tests to make an exhaustive study of the value of diagnosis of ovarian infection by this method, but it has been of importance to determine by it if possible the number of these hens infected, to use as a check on the work on agglutination which was to follow.

Therefore, according to these tests hens Nos. 10, 8, 6, 5, 2, 52, 13, 792, 714, 8, 1, 2096, 7, 48 and 464 are all infected hens, the organism having been demonstrated conclusively in their eggs. It should also be stated that prior to starting experiments with these birds the organism had been detected in hen No. 267. From our work just cited it can be seen that in those hens which did lay eggs containing *Bact. pullorum*, the elimination from the ovary was so irregular that it would be impossible to make a diagnosis in a short time.

Since there was at hand such good material for study it was considered of importance to study the macroscopic agglutination test, as suggested by Jones[1, 2], — as regards the practicability of the tests, the test fluids and important steps to be observed in making the diagnosis, — and to carry out the test with three laboratory technicians to determine the value of this macroscopic test as a laboratory procedure for the diagnosis of this infection in adult hens.

This test depends upon the specific agglutinin elaborated in the blood serum of hens harboring the organism. The test requires a test fluid containing a suspension of *Bacterium pullorum* in 0.85 per cent. salt solution, preserved with 0.5 per cent. carbolic acid, and the specific agglutinin, diluted in varying amounts from suspected individuals. The agglutinins act on dead as well as living organisms.

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[1] Jones, F. S.: Report, New York State Veterinary College for 1910–11, p. 76.

[2] Jones, F. S.: "The value of the macroscopic agglutination test in detecting fowls that are harboring *Bact. pullorum*." Journal Medical Research, Vol. XXVII., No. 4; N. S., Vol. XXII., No. 4, pp. 485–495.

TABLE 5.

HEN NO.	No. OF EGGS LAID BEFORE B. PULLORUM WAS DETECTED	LAYING PERIOD IN DAYS
10	11	20
18	8	16
6	5	6
5	12	20
2	7	16
52	7	10
13	8	15
792	5	8
714	4	12
8	21	39
1	13	38
2096	21	33
7	11	24
48	19	58
464	12	61

From some preliminary tests it was found that the living test fluids gave little better results. For this reason it was decided to carry out our work, using the living organisms in preparing the various test fluids.

The Test Fluid.

Before preparing any of our test fluids for these macroscopic agglutination reactions, all strains of *Bacterium pullorum* were thoroughly tested out to establish their pathogenic powers. The *Bacterium pullorum* material had been isolated from 7 different sources, and was designated S_1 (Strain No. 1) S_2, S_3, S_4, S_5, S_6 and S_7, and represented cultures of *Bacterium pullorum* isolated by the author from chicks which had died of the disease from an infected flock of hens in western Massachusetts; from another chick, dead of the disease; from an infected flock of more than 400 hens from eastern Massachusetts; from a fresh egg laid by a hen in this infected flock; from the ovarian tissue of a badly infected hen in the State of Maryland; from a chick which had died after experimental inoculation with a pure culture isolated from ovarian tissue; from a strain isolated from Connecticut epidemics and furnished to the author three years ago by Dr. Rettger of Yale University. The last, or Strain No. 7, was recovered from a local epidemic. These strains were all carefully examined for purity, and after due time were obtained in a very active state of growth. Strain No. 4 was finally not used because it appeared to have lost so much of its virulence.

For testing the virulence of these 6 strains of *Bacterium pullorum* 154 day-old chicks, hatched July 10, 1913, were used. They were divided into 7 lots, 22 in each lot. Six of these sets were inoculated with *Bact. pullorum* and the seventh was used for control. The chicks were fed sterilized food and water and were retained in wire animal cages and brooded with stone jugs containing hot water. The litter used was fine shavings which had been sterilized and spread in a layer over floor of cages prior to putting the chicks in. Each chick in the lots to be infected received $\frac{1}{4}$ c.c. of a physiological saline suspension of the various strains of *Bacterium pullorum* subcutaneously. The control lot received $\frac{1}{4}$ c.c. sterile physiological salt solution administered in the same manner. Chicks in pen No. 1 were inoculated with S_1; chicks in pen No. 2, with S_2; chicks in pen No. 3, with S_3; chicks in pen No. 4, with S_5; chicks in pen No. 5, with S_6; chicks in pen No. 6, with S_7; and the chicks in pen No. 7 were the controls.

As soon as chicks died they were carefully autopsied and the liver, heart, unabsorbed yolk and calcar examined for presence of *Bacterium pullorum*. In Table 6 are arranged the mortality records which furnish the evidence of the pathogenicity of these various strains. From each chick, dead of the disease, cultures were retained, and in Table 6 P. signifies that the cultures were recovered from the respective organs in an absolutely pure state. Wherever there is a denotation N.P. it signifies that culture recovered was not pure. However, in no case did

the contaminating factor so outgrow or obscure the colony of *Bacterium pullorum* but that it was possible to recover it from some of the tubes. At this point it is sufficient to say that the symptoms — pre-mortem and post-mortem findings of chicks dead of the disease — correspond with those previously studied by the author.[1]

After twenty-five days the tests were considered completed, and Strains Nos. 1, 2, 3, 5, 6 and 7 were all in perfect condition to continue the work with the agglutinations. Pen No. 7, the control lot, never showed any signs of disease, and until a few weeks ago (Dec. 1, 1913) 20 of the 22 were living, healthy, vigorous birds. Only two deaths occurred among the 22 control chicks; one was accidental and the other was killed on account of lameness.

Making the Test Fluid.

Slant agar tubes were inoculated with *Bact. pullorum* and grown in incubator at 38° C. for one or two days. The growth was then washed with carbolated salt solution (0.85 per cent. salt solution containing 0.5 per cent. carbolic acid). The whole volume of washed material should have a very definite cloudy appearance. This was put in the shaking machine and shaken for one-half hour and then passed through sterile absorbent cotton to strain out any clumps of bacteria which might remain. Care should always be observed not to prepare the suspension too thin. A good test fluid should be uniformly turbid. This should be retained on ice or in lower part of refrigerator.

Method of obtaining Blood Serum.

At first the method of cutting a spike of the comb was employed, but since the bird's blood coagulates so quickly if in contact with tissue this was found unsatisfactory. Then the method of cutting the wing vein was employed, and by working carefully with this method it was found to be suitable in every respect for drawing blood in 2 to 10 c.c. quantities, causing but little effect upon the bird. At first great care was used in cutting through the cutaneous tissue until the *vena ulnaris* was reached, and the tissue teased away to make a clean cutting surface for making the incision into the vein. By such treatment it was possible to get the blood under quite ideal conditions, but the bird was submitted to considerable discomfort. Finally it was found that the quicker the cut was made the better the results, and less discomfort for the individual. The procedure finally adopted for drawing about 6 c.c. of blood in a very short time, and one which appeared to cause the individual no apparent discomfort, nor disturb the egg laying later on, was carried out as follows: the bird was laid on its side and the wing laid out near the edge of the table and turned downward to afford a grade for the sample of blood to flow into test tube.

[1] Gage, Geo. Edward: "Notes on ovarian infection with *Bacterium pullorum* (Rettger) in the domestic fowl." Journal Medical Research, Vol. XXIV., No. 3; N. S. Vol. XIX., No. 3; June, 1911, pp. 491–496.

TABLE 6.

Mortality Records of chicks on test to demonstrate pathogenicity of Bacterium pullorum S_1, S_2, S_3, S_5, S_6 and S_7

Pen no 1 - chicks inoculated subcutaneously with 0.25 c.c. physiological saline suspension Bact. pullorum Strain 1 22 in number.
(SEE LEGEND AT BOTTOM OF TABLE)

Chick No.	Date of Death	Heart	Liver	Unabsorbed Yolk	Caeca	Cultures Purified and Filed as No.
1	7-13-13	+ N.P.	+ P	—	—	H 1
2	7-13-13	+ N.P	+ N.P	+ N.P.	+ N.P.	H 2 L 3
3	7-13-13	+ P	+ P	+ NP	+ NP	H 4 L 5 U 6
4	7-14-13	+ N.P	+ NP	+ P		U 7
5	7-14-13	+ P	+ N P	+ N.P	+ N.P	H 8 L 9
6	7-14-13	+ N.P.	+ N.P.	+ NP	—	H 10 L 11
7	7-14-13	+ P	+ P	+ NP	+ N.P.	H 12 L 13 U 14
8	7-14-13	+ N.P.	+ N.P.	+ N.P.	+ N.P.	L 15 U 16 C 17
9	7-14-13	+ P	+ P	+ N.P	+ N.P.	H 18 L 19 U 20
10.	7-14-13	+ N.P.	+ N.P.	+ N.P	+ N.P.	L 21 U 22
11.	7-15-13	+ P	+ N.P	+ P	+ NP	H 23 L 24 U 25
12	7-15-13	+ N.P.	+ N.P	+ N.P	+ NP	H 26 L 27 U 28 C 29
13	7-15-13	+ P	+ P	+ P	+ N.P.	H 30 L 31 U 32
14	7-16-13	+ N.P.	+ P.	+ N.P.	+ N.P	L 33
15	7-16-13	+ N.P.	+ N.P.	+ N.P.		H 34 L 35 U 36
16	7-16-13	+ N.P	+ N.P.	+ N.P	+ N.P	H 37 L 38 U 39
17	7-16-13	— NP	— NP	+ NP		U 40
18	7-16-13	+ P	+ P	+ N.P.	— N.P.	H 41 L 42 U 43
19	7-17-13	+ N.P.	+ N.P.			H 44 L 45
20						
21						
22						

Pen no 2 - chicks inoculated subcutaneously with 0.25 c.c physiological saline suspension Bact. pullorum Strain 2 22 in number

Chick No.	Date of Death	Heart	Liver	Unabsorbed Yolk	Caeca	Cultures Purified and Filed as No.
1	7-12-13	—	—	—	-	
2	7-14-13	— NP	+ N.P	+ P	— NP	L 46 U 47
3	7-14-13	+ N.P	+ N.P	+ NP	— N.P.	H 48 L 49 U 50
4	7-15-13	+ P	+ P	+ NP	+ N.P.	H 51 L 52 U 53
5	7-15-13	+ N.P	+ N.P	+ N.P	— N.P	H 54 L 55 U 56
6	7-1-13	1 NP	+ P	+ N.P	+ NP	L 57
7	7-16-13	+ NP	+ P	+ P		H 58 L 59 U 60
8	7-16-13	+ N.P.	+ NP	+ P	+ NP	H 61 L 62 U 63
9	7-16-13	+ NP	+ NP	+ P	+ NP	H 64 U 65
10	7-16-13	+ P	+ P	+ NP	+ NP	H 66 L 67
11	7-16-13	+ P	+ NP	+ P	+ P	H 68
12	7-17-13	+ NP	+ NP	?		U 69
13	7-17-13	+ P	+ P	+ NP	— NP	H 70 L 71 U 72
14	7-17-13	+ NP	+ NP			H 73
15	7-17-13	+ NP	+ NP	+ NP	+ NP	L 74 U 75 C 76
16	7-17-13	1	+ NP	+ NP	1 NP	U 77
17	7-17-13	+ NP	+ P	+ P	+ NP	L 78 U 79
18	7-18-13	+ NP	+ NP	+ NP	+ NP	L 80 U 81
19	7-21-13	+ P	+ P	+ NP	+ NP	L 82
20	7-23-13	+ NP	— NP	+ NP	+ NP	H 83
21						
22						

Pen no 3. - chicks inoculated subcutaneously with 0.25 c.c. physiological saline suspension Bact. pullorum Strain 3. 22 in number

Chick No.	Date of Death	Heart	Liver	Unabsorbed Yolk	Caeca	Cultures Purified and Filed as No.	Chick No.
1	7-12-13	—	—	—	—		1
2	7-14-13	— NP	+ NP	+ P	+ NP	H 84 L 85 U 85	2
3	7-14-13	— NP	+ P	+ NP	+ NP	L 87	3
4	7-14-13	— NP	+ NP	+ NP	+ NP	H 88 L 89	4
5	7-15-13	— NP	+ P	+ NP	+ NP	H 90 L 91 U 92	5
6	7-15-13	+ P	+ NP	+ NP	+ NP	H 93 L 94 C 95	6
7	7-16-13	+ NP	+ NP	+ NP	+ NP	U 96	7
8	7-16-13	+ NP	+ P	+ NP	+ NP	L 97	8
9	7-16-13	+ NP	+ NP	+ NP	+ NP	H 98 L 99 U 100	9
10	7-16-13	— NP	?	+ NP	?	H 101 U 102	10
11	7-16-13	+ NP	+ NP	+ NP	+ NP	H 103 L 104 U 105	11
12	7-16-13	+ P	+ P	+ P	+ NP	H 106 L 107 U 108 C 109	
13	7-17-13	+ P	+ NP	+ NP	+ NP	H 110 L 111 U 112	
14	7-17-13	?	+ P	+ NP	+ NP	L 113 U 114	
15	7-17-13	— NP	+ NP	+ NP	+ NP	L 115 U 116	
16	7-17-13	+ NP	—	+ NP	+ NP	H 117	
17	7-17-13	+ P	+ NP	+ NP	+ NP	H 118 L 119	
18	7-19-13	— NP	+ NP	+ NP	+ NP	H 120	
19	7-22-13	+ P	+ P	+ P	+ NP	H 121 L 122 U 123	

Pen no 4 - chicks inoculated subcutaneously with 0.25 c.c physiological saline suspension Bact pullorum Strain 5. 22 in number

Chick No.	Date of Death	Heart	Liver	Unabsorbed Yolk	Caeca	Culture Purified and Filed as No.
1	7-13-13	— NP	+ NP	— NP	?	L 124
2	7-14-13	+ NP	+ NP	+ NP	+ NP	H 125 L 126 U 127 C 128
3	7-15-13	+ NP	+ NP	+ NP	+ NP	H 129 L 130
4	7-16-13	—	+ NP	—	+ NP	H 131 L 132 C 133
5	7-16-13	+ NP	+ P	+ NP	?	H 134 L 135 U 136
6	7-16-13	+ P	+ NP	+ P	+ NP	H 137 L 138 U 139 C 140
7	7-16-13	+ NP	+ NP	+ NP	+ NP	H 141 L 142 U 143 C 140
8	7-16-13	— NP	+ NP	+ NP	—	L 145 U 146
9	7-17-13	—	+ NP	+ NP	?	L 147 U 148
10	7-17-13	?	+ NP	+ NP	?	L 149 U 150
11	7-17-13	?	+ NP	+ P	+ NP	L 151 U 152 C 153

Pen no 5 - Chicks inoculated subcutaneously with 0.25 c.c physiological saline suspension Bact. pullorum Strain 6 22 in number.

Chick No.	Date of Death	Heart	Liver	Unabsorbed Yolk	Caeca	Cultured Purified and Filed as No.
1	7-12-13	+ P	+ NP	+ P	+ NP	H 154 L 155 U 156
2	7-13-13	+ P	+ NP	+ P	+ NP	L 157 U 158
3	7-14-13	+ NP	+ P	+ NP	+ P	L 159 U 160
4	7-15-13	+ P	+ P	+ NP	+ P	L 161 U 162
5	7-15-13	+ P	+ P	+ P	+ P	H 163 L 164
6	7-15-13	+ P	+ P	+ P	+ P	H 165 L 166
7	7-15-13	+ P	+ NP	+ P	+	H 167 U 168
8	7-15-13	+ P	+ NP	+ P	+ NP	H 169 L 170 U 171 C 172
9	7-15-13	+ P	+ NP	+ P	+ NP	H 173 L 174 U 175
10	7-15-13	+ P	+ NP	+ P	+ NP	H 176 L 177 U 178
11	7-16-13	+ P	+ P	+ NP	+ NP	H 179 L 180 U 181
12	7-16-13	+ P	+ NP	+ P	+ NP	H 182 L 183
13	7-16-13	+ P	+ NP	+ P	+ NP	H 184 L 185 U 186
14	7-16-13	+ NP	+ NP	+ P	+ NP	U 187

Pen no 6 - Chicks inoculated subcutaneously with 0.25 c.c physiological saline suspension Bact pullorum Strain 7, 22 in number

Chick No.	Date of Death	Heart	Liver	Unabsorbed Yolk	Caeca	Culture Purified and Filed as No.
1	7-13-13	+ NP	—	+ NP	?	H 188 U 189
2	7-14-13	+ NP	— NP	+ P	?	H 190 U 191
3	7-15-13	+ NP	+ NP	+ NP	+ NP	H 192 U 193
4	7-15-13	+ P	+ NP	+ NP	+ NP	H 194 L 195
5	7-16-13		+ P	+ P	· NP	L 196 U 197
6	7-16-13	+ NP	+ NP	+ NP	+ NP	L 198
7	7-16-13	—	— NP	+ P	+ NP	H 199 L 200 U 201 C 202
8	7-16-13	+ P	+ P	+ NP	+ NP	H 203 L 204 U 205
9	7-16-13	+ NP	+ NP	+ NP	+ NP	L 206 U 207
10	7-17-13	+ NP	+ NP	+ NP	?	H 208 U 209
11	7-17-13		+ NP	+ NP	+ NP	L 210 U 211
12	7-18-13	+	+ NP	+ NP		L 212 U 213
13	7-21-13	+ NP	+ NP	+ NP		H 214 L 215 U 216
14	7-25-13	—	—	—	—	
15	7-28-13	—	+ P		—	L 217

LEGEND
+ = Bacterium pullorum detected
— = Bacterium pullorum not detected
P = signifies isolated in absolutely pure culture
NP = signifies culture showed some sign of contamination
H = culture isolated from heart
L = Culture recovered from liver
U = Culture isolated from unabsorbed yolk
C = culture recovered from caeca. (signifying from either right or left)

The finger of the operator was placed under the *vena ulnaris*, between the ulnal and radial bones near the distal ends, and pressed until the vein by distention shows plainly. Then having sterilized the part, and using sterile fine scissors, a cut was made through the cutaneous tissue into the vein, making a short cut longitudinally. The blood will flow out in large drops, and can be easily collected into a test tube, and by using a pledget of cotton moistened with 1–40 carbolic acid the flow of blood can be quickly stopped, and then by placing a dry piece of cotton over the incision and closing the wing down tightly, in a few minutes the individual may be returned to the pen. Blood thus obtained is allowed to clot, and the serum is later drawn off as a straw-colored supernatant fluid. This is then diluted with carbolated salt solution to the usual stock dilution 1–20.

Making the Agglutination Test.

Small test tubes 4 inches long and $\frac{1}{2}$-inch calibre were used. During some of our preliminary tests 3 c.c. test fluid was used as suggested by Jones,[1] but it was found after several sets had been tried out that 1.5 c.c. of the test fluid gave equally good results. The dilutions used most were 1–100, 1–200 and 1–500, but in some of the work test dilutions from 1–100 to 1–5,000 were used and made as follows: all sera were diluted 1–20, and then by a simple algebraic calculation the amount of diluted (1–20) serum necessary to add to 1.5 c.c. test fluid to make a desired dilution was determined. For example, 1.5 c.c. test fluid + .3 c.c. (1–20 serum) = dilution 1–100 desired. The following amounts of diluted 1–20 serum were added to 1.5 c.c. test fluid to make required dilutions: —

1– 100 = .3 c.c. diluted serum 1–20.
1– 200 = .15 c.c. diluted serum 1–20.
1– 300 = .099 c.c. diluted serum 1–20.
1– 400 = .075 c.c. diluted serum 1–20.
1– 500 = .06 c.c. diluted serum 1–20.
1– 800 = .037 c.c. diluted serum 1–20.
1–1,000 = .03 c.c. diluted serum 1–20.
1–1,200 = .025 c.c. diluted serum 1–20.
1–1,500 = .019 c.c. diluted serum 1–20.
1–1,800 = .016 c.c. diluted serum 1–20.
1–2,000 = .015 c.c. diluted serum 1–20.
1–2,500 = .012 c.c. diluted serum 1–20.
1–3,000 = .009 c.c. diluted serum 1–20.
1–4,000 = .007 c.c. diluted serum 1–20.
1–5,000 = .006 c.c. diluted serum 1–20.

Three sets of graduated pipettes were used, the first, a 5 c.c. graduated to $\frac{1}{10}$ c.c.; the second, graduated to $\frac{1}{100}$ c.c. The pipette graduated to $\frac{1}{100}$ c.c. was used to make dilutions up to 1–500, and for dilutions 1–500 to 1–5,000 one divided into $\frac{1}{1000}$ of c.c. was employed. After having made

[1] Jones, F. S.: "The value of the macroscopic agglutination test in detecting fowls that are harboring *Bact. pullorum*." Journal Medical Research, Vol. XXVII., No. 4; N. S., Vol. XXII., No. 4, pp. 485-495.

the desired dilution and thoroughly shaken each tube to afford a complete mixture of the agglutinative sera and *Bacterium pullorum* all was placed in the bacteriological incubator at 38° and readings made of the macroscopic agglutinative picture at the end of twenty-four, forty-eight and seventy-two hours. All tests were controlled, *i.e.*, test fluid and agglutinative sera.

A positive macroscopic agglutination reaction is evident when the formation of fine, flake-like masses settle to the bottom of the tube into uneven heaped-up masses at the bottom and sides, leaving the supernatant fluid clear. This reaction is usually very prompt, and with sera of marked potency it is very clear and definitely defined. Controls should always be kept for check of test fluid, and check of diluted serum in carbolated salt solution.

The test fluid used for our work at first was composed of the 6 tested strains of *Bacterium pullorum* preserved by 0.5 per cent. carbolic acid and kept on ice. The serum was used continuously until no positive reactions would result in a serum known to be positive, and from this it was possible to determine about how long a serum could be retained under proper conditions and be in an active state for use in making the test.

In tables 7 and 8 which follow can be seen the results of the macroscopic tests on the birds carried out by three different technicians working independently. The technician is denoted in the column of that legend as 1, 2 and 3. It is indeed interesting to note that the work of the three technicians checks very well, and from the summary of the work of each no difference ever arose as to whether a bird was or was not a reactor. Hens Nos. 267, 8, 1, 10, 6, 2096, 10, 18, 6, 2, 48, 7, 13, 53, 792, 714, 464 and 61 were all proven by all three technicians to be infected hens, having the agglutinin present, varying in its powers to cause agglutination of *Bacterium pullorum*. From tables 7 and 8 it can be seen that with the results in the agglutination work, especially the tests made with the blood drawn on July 19, and with the serum of hens Nos. 267, 2, 10, 2096, 5, 2, 48, 52, 53, 452, 792, 714 and 464, the serum reactions were consistent with the three technicians until the seventeenth or eighteenth days, when the reactions began to vary considerably. This is indeed an interesting feature in favor of the test, and it is possible, under better conditions of preservation, that it may be kept longer. After the hundreds of tests made in this laboratory it would be safe to state that properly preserved and cooled agglutinative sera may be retained in a good state for subsequent tests for as long as two weeks. On the other hand, a carefully prepared test fluid, made from newly incubated cultures of *Bact. pullorum*, and suspended in 0.85 per cent. physiological saline solution containing 0.5 per cent. phenol, if retained on ice will remain in good condition for making the tests even after two months.

In some instances a serum retained for three weeks, when used by one technician on the 6th of August reacted, and had lost its agglutinative powers on the 7th when used by another technician. At the beginning

Table 8.

AGGLUTINATION TESTS MADE WITH BLOOD SERUM REMOVED AUG 11, 1913. AND A TEST FLUID COMPOSED OF S_1, S_2, S_3, S_5, S_6, AND S_7.

Hen	Date	Technician	Hours	← Dilutions →
HEN 267	8/2	2	24	- - - - - - - - - - - - - - -
	8/2	2	48	- - - - - - - - - - - - - - -
	8/2	2	72	- - - - - - - - - - - - - - -
	8/16	2	24	+ - - - - - - - - - - - - - -
	8/16	2	48	+ - - - - - - - - - - - - - -
	8/16	2	72	+ + - - - - - - - - - - - - -
	8/19	2	24	+ + - -
	8/19	2	48	+ + - -
	8/19	2	72	+ + - -
	8/20	1	24	+ + + + +
	8/20	2	24	+ - - -
	8/20	1	48	
	8/20	2	48	+ + - -
	8/20	1	72	+ + - - -
	8/20	2	72	+ + + -
	8/25	2	24	- - - - -
	8/25	2	48	- - - - -
	8/25	2	72	+ + - - -
HEN 8	8/2		24	
	8/2		48	
	8/2		72	
	8/16	2	24	+ + + + + + + + + - - - - - -
	8/16	2	48	+ + + + + + + + + - - - - - -
	8/16	2	48	+ + + + + + + + + - - - - - -
	8/19	2	24	+ + + + + + +
	8/16	2	48	+ + + + + + +
	8/19	2	72	+ + + + + + +
	8/20	1	24	+ + + + + + +
	8/20	2	24	+ + + + + + +
	8/20	1	48	+ + + + + + +
	8/20	2	48	+ + + + + + +
	8/20	1	72	+ + + + + + +
	8/20	2	72	+ + + + + + +
	8/25	2	24	+ + + + + + + + +
	8/25	2	48	+ + + + + + + + +
	8/25	2	72	+ + + + + + + + +
HEN 315	8/13	2	24	- - - - - - - - - - - - - - -
	8/13	2	48	- - - - - - - - - - - - - - -
	8/13	2	72	
	8/17	1	24	- - - - - - - - - - - - - - -
	8/19	2	24	- - - - - - - - - - - - - - -
	8/19	1	48	- - - - - - - - - - - - - - -
	8/19	2	48	- - - - - - - - -
	8/17	1	72	- - - - - - - - -
	8/19	2	72	- - - - - - - - -
	8/20	1	24	- - - - - - - - -
	8/20	2	24	- - - - - - - - -
	8/20	1	48	
	8/20	2	48	- - - - - - - - -
	8/20	1	72	
	8/20	2	72	- - - - - - - - -
	8/25	2	24	- - - - - - - - -
	8/25	2	48	- - - - - - - - -
	8/25	2	72	- - - - - - - - -
HEN 1	8/2	2	24	- - - - - - - - -
	8/2	2	48	- - - - - - - - -
	8/2	2	72	+ + + + + + + - -
	8/17	1	24	+ + + + + + + - - - - - - - -
	8/19	2	24	
	8/17	1	48	+ + + + + + + + + + + + + + +
	8/19	2	48	+ + + + + + +
	8/17	1	72	
	8/19	2	72	+ + + + + + +
	8/22	1	24	+ + + + +
	8/20	2	24	+ + +
	8/22	1	48	+ + + + +
	8/20	2	48	+ + + +
	8/22	1	72	
	8/20	2	72	+ + + +
	8/25	2	24	+ + + +
	8/25	2	48	+ + + + +
	8/25	2	72	+ + + + + - -
HEN 49	8/2	2	24	- - - - - - - - - - -
	8/2	2	48	- - - - - - - - - - -
	8/2	2	72	- - - - - - - - - - -
	8/16	2	24	- - - - - - - - - - -
	8/16	2	48	- - - - - - - - - - -
	8/16	2	72	- - - - - - - - - - -
	8/19	2	24	- - - -
	8/19	2	48	- - - -
	8/19	2	72	- - - -
	8/20	1	24	- - - - -
	8/20	2	24	- - - -
	8/20	1	48	- - - - -
	8/20	2	48	- - - -
	8/20	1	72	- - - - -
	8/20	2	72	- - - -
	8/25	2	24	- - - -
	8/25	2	48	- - - - - - -
	8/25	2	72	- - - - - - -
HEN 60	8/13	2	24	- - - - - - - - - - - - - - -
	8/13	2	48	- - - - - - - - - - - - - - -
	8/13	2	72	
	8/17	1	24	- - - - - - - - - - - - - - -
	8/19	2	24	- - - - -
	8/17	1	48	- - - - - - - - - - - - - - -
	8/19	2	48	- - - -
	8/17	1	72	
	8/19	2	72	- - - -
	8/20	1	24	- - - - -
	8/20	2	24	- - - -
	8/20	1	48	- - - - -
	8/20	2	48	- - - -
	8/20	1	72	- - - - -
	8/20	2	72	- - - -
	8/25	2	24	- - - -
	8/25	2	48	- - - -
	8/25	2	72	- - - -
HEN 22	8/2	2	24	- - - - - - - - - - - - - - -
	8/2	2	48	- - - - - - - - - - - - - - -
	8/2	2	72	- - - - - - - - - - - - - - -
	8/16	2	24	- - - - - - - - - - - - - - -
	8/16	2	48	- - - - - - - - - - - - - - -
	8/16	2	72	- - - - - - - - - - - - - - -
	8/19	2	24	- - - -
	8/19	2	48	- - - -
	8/19	2	72	- - - -
	8/20	1	24	- - - -
	8/20	2	24	- - - -
	8/20	1	48	- - - - -
	8/20	2	48	- - - -
	8/20	1	72	- - - - -
	8/20	2	72	- - - -
	8/25	2	24	- - - - -
	8/25	2	48	- - - - - - -
	8/25	2	72	- - - - - - -
HEN 10	8/2	2	24	
	8/2	2	48	
	8/2	2	72	
	8/16	2	24	+ + + - - - - - - - -
	8/16	2	48	+ + + + - - - - - -
	8/16	2	72	+ + + + + - - - - -
	8/19	2	24	+ + + +
	8/19	2	48	+ + + +
	8/19	2	72	+ + + +
	8/20	1	24	+ + + + +
	8/20	2	24	+ + + -
	8/20	1	48	+ + + + +
	8/20	2	48	+ + + +
	8/20	1	72	+ + + + +
	8/20	2	72	+ + + +
	8/25	2	24	+ + + + +
	8/25	2	48	+ + + + +
	8/25	2	72	+ + + + +
HEN 18	8/13	2	24	
	8/13	2	48	
	8/13	2	72	
	8/19	2	24	- - - -
	8/19	2	48	+ + + +
	8/19	2	72	+ + + +
	8/17	1	24	+ + + + + + + + + + + - - - -
	8/17	1	48	+ + + + + + + + + + + + + - -
	8/20	1	24	+ + + +
	8/20	2	24	+ + + +
	8/20	1	48	
	8/20	2	48	+ + + +
	8/20	1	72	+ + + + +
	8/20	2	72	+ + + +
	8/25	2	24	+ + + + +
	8/25	2	48	+ + + + + - -
	8/25	2	72	+ + + + + - -
HEN 77	8/2	2	24	- - - - - - - - - - - - - - -
	8/2	2	48	- - - - - - - - - - - - - - -
	8/2	2	72	- - - - - - - - - - - - - - -
	8/17	1	24	- - - - - - - - - - - - - - -
	8/19	2	24	- - - -
	8/17	1	48	- - - - - - - - - - - - - - -
	8/19	2	48	- - - -
	8/17	1	72	
	8/19	2	72	- - - -
	8/20	1	24	- - - - -
	8/20	2	24	- - - -
	8/20	1	48	
	8/20	2	48	- - - -
	8/20	1	72	- - - - -
	8/20	2	72	- - - -
	8/25	2	24	- - - - -
	8/25	2	48	- - - - -
	8/25	2	72	- - - - -
HEN 6	8/13	2	24	+ + + + - - - - - - - - - - -
	8/13	2	48	+ + + + - - - - - - - - - - -
	8/13	2	72	+ + + + + + + + + - - - - - -
	8/16	2	24	+ + + + + - - - - - - - - - -
	8/16	2	48	+ + + + + - - - - - - - - - -
	8/16	2	72	+ + + + + + + + + - - - - - -
	8/19	2	24	+ + + +
	8/19	2	48	+ + + +
	8/19	2	72	+ + + +
	8/20	1	24	+ + + + +
	8/20	2	24	+ + - -
	8/20	1	48	+ + + + +
	8/20	2	48	+ + + -
	8/20	1	72	+ +
	8/20	2	72	+ + + +
	8/25	2	24	+ + + + +
	8/25	2	48	+ + + + + +
	8/25	2	72	+ + + + + +
HEN 2096	8/2	2	24	+ + - - - - - - - - - - - - -
	8/2	2	48	+ + - - - - - - - - - - - - -
	8/2	2	72	+ + - - - - - - - - - - - - -
	8/16	2	24	+ + - - - - - - - - - - - - -
	8/16	2	48	+ - - - - - - - - - - - - - -
	8/16	2	72	+ + - - - - - - - - - - - - -
	8/19	2	24	+ - - - - -
	8/19	2	48	+ - - - - -
	8/19	2	72	+ - - - - -
	8/20	1	24	+ + - - -
	8/20	2	24	- - - -
	8/20	1	48	+ + + - -
	8/20	2	48	- - - -
	8/20	1	72	+ + + - -
	8/20	2	72	- - - -
	8/25	2	24	- - - - - - -
	8/25	2	48	- - - - - - -
	8/25	2	72	- - -
HEN 2	8/16	2	24	+ + +
	8/16	2	48	+ + + + + + + - - - - - - - -
	8/16	2	72	+ + + + + + + + + - - - - - -
	8/19	2	24	+ + + +
	8/19	2	48	+ + + +
	8/19	2	72	+ + + +
	8/20	2	24	+ + + +
	8/22	2	24	+ + + + -
	8/20	2	48	+ + + +
	8/22	1	48	+ + + + -
	8/20	2	72	+ + + +
	8/22	1	72	
	8/25	2	24	+ + + + +
	8/25	2	48	+ + + + +
	8/25	2	72	+ + + + + - -
HEN 4	8/13	2	24	- - - - - - - - - - - - - - -
	8/13	2	48	- - - - - - - - - - - - - - -
	8/17	1	24	- - - - - - - - - - - - - - -
	8/19	2	24	- - - - - - - - - - - - - - -
	8/17	1	48	- - - - - - - - - - - - - - -
	8/19	2	48	- - - - - - - - - - - - - - -
	8/17	1	72	- - - - - - - - - - - - - - -
	8/19	2	72	- - - - - - - - - - - - - - -
	8/20	1	24	- - - - - - - - - - - - - - -
	8/20	2	24	- - - - - - - - - - - - -
	8/20	1	48	- - - - - - - - - - - - -
	8/20	2	48	- - - - - - - - - - - - -
	8/20	1	72	- - - - - - - - - - - - -
	8/20	2	72	- - - - - - - - - - - - -
	8/25	2	24	- - - - - - - - - - - - -
	8/25	2	48	- - - - - - - - - - - - -
	8/25	2	72	- - - - - - - - - - - - -
HEN 35	8/13	2	24	- - - - - - - - - - - - - - -
	8/13	2	48	- - - - - - - - - - - - - - -
	8/13	2	72	
	8/17	1	24	- - - - - - - - - - - - - - -
	8/19	2	24	- - - -
	8/17	1	48	- - - - - - - - - - - - - - -
	8/19	2	48	- - - -
	8/19	1	72	
	8/19	2	72	- - - - - -
	8/20	1	24	- - - - -
	8/20	2	24	- - - -
	8/20	1	48	-
	8/20	2	48	- - - -
	8/20	1	72	- - - - -
	8/20	2	72	- - - -
	8/25	2	24	- - - -
	8/25	2	48	- - - -
	8/25	2	72	- - - -
HEN 48	8/16	2	24	+ + + + + + + - - - - - - - -
	8/16	2	48	+ + + + + + + - - - - - - - -
	8/16	2	72	+ + + + + + + - - - - - - - -
	8/19	2	24	+ + + +
	8/19	2	48	+ + + +
	8/19	2	72	+ + + +
	8/20	1	24	+ + - - -
	8/20	2	24	+ - - - -
	8/20	1	48	+ + + - -
	8/20	2	48	+ - - -
	8/20	1	72	+ + + - -
	8/20	2	72	+ + - -
	8/25	2	24	- - - - -
	8/25	2	48	- - - - - - -
	8/25	2	72	- - - - - - -
HEN 618	8/13	2	24	- - - - - - - - - - - - - - -
	8/13	2	48	- - - - - - - - - - - - - - -
	8/13	2	72	
	8/17	1	24	- - - - - - - - - - - - - - -
	8/19	2	24	- - - - -
	8/17	1	48	- - - - - - - - - - - - - - -
	8/19	2	48	- - -
	8/17	1	72	
	8/19	2	72	- - - -
	8/20	1	24	- - - - -
	8/20	2	24	- - - -
	8/20	1	48	
	8/20	2	48	- - - -
	8/20	1	72	- - - - -
	8/20	2	72	- - - -
	8/25	2	24	- - - - -
	8/25	2	48	- - - - - - -
HEN 7	8/2	2	24	+ + + + + + + + + + - - - - -
	8/16	2	48	+ + + + + + + + + + - - - - -
	8/16	2	72	+ + + + + + + + + - - - - - -
	8/19	2	24	+ + + +
	8/19	2	48	+ + + +
	8/19	2	72	+ + + +
	8/20	1	24	+ + + + +
	8/20	2	24	+ + + +
	8/20	1	48	+ + + + +
	8/20	2	48	+ + + +
	8/20	1	72	+ + + + +
	8/20	2	72	+ + + +
	8/25	2	24	+ + + + +
	8/25	2	48	+ + + + + - -
	8/25	2	72	+ + + + + - -
HEN 46	8/2	2	24	- - - - - - - - - - - - - - -
	8/2	2	24	- - - - - - - - - - - - - - -
	8/2	2	72	- - - - - - - - - - - - - - -
	8/16	2	24	- - - - - - - - - - - - - - -
	8/16	2	48	- - - - - - - - - - - - - - -
	8/16	2	72	- - - - - - - - - - - - - - -
	8/19	2	24	- - - -
	8/19	2	48	- - - -
	8/19	2	72	- - - -
	8/20	1	24	- - - - -
	8/20	2	24	- - - -
	8/20	1	48	- - - - -
	8/20	2	48	- - - - -
	8/20	1	72	- - - - -
	8/20	2	72	- - - -
	8/25	2	24	- - - - -
	8/25	2	48	- - - - - - -
	8/25	2	72	- - - - - - -
HEN 13	8/17	1	24	+ + + + + + + - - - - - - - -
	8/19	2	24	+ + + +
	8/17	1	48	+ + + + + + - - - - - - - - -
	8/19	2	48	+ + + +
	8/17	1	72	
	8/19	2	72	+ + + +
	8/20	2	24	+ + - -
	8/20	1	24	+ + + + +
	8/20	1	48	+ + + + +
	8/20	2	48	+ + + +
	8/20	1	72	+ + + + +
	8/20	2	72	+ + + +
	8/25	2	24	+ + + +
	8/25	2	48	+ + + + + + - -
	8/25	2	72	+ + + + + + - -
HEN 53	8/19	2	24	- - - -
	8/19	2	48	+ + + +
	8/19	2	72	+ + + +
	8/20	2	24	
	8/20	2	48	+ + + +
	8/20	2	72	+ + + +
	8/25	2	24	+ + + + - -
	8/25	2	48	+ + + + +
	8/25	2	72	+ + + + +
HEN 792	8/20	1	24	+ + + - -
	8/20	2	24	- - - - -
	8/20	1	48	+ + + + +
	8/20	2	48	- - - -
	8/20	1	72	+ + - - -
	8/20	2	72	- - - -
	8/25	2	24	- - - - -
	8/25	2	48	- - - - - - -
	8/25	2	72	- - - - - - -
HEN 714	8/16	2	24	+ - - - - - - - - - - - - - -
	8/16	2	48	+ - - - - - - - - - - - - - -
	8/16	2	72	+ - - - - - - - - - - - - - -
	8/19	2	24	+ - - -
	8/19	2	48	+ + - -
	8/19	2	72	+ + - -
	8/20	1	24	+ + + - -
	8/20	2	24	+ - - -
	8/20	1	48	+ + + - -
	8/20	2	48	+ + - -
	8/20	1	72	+ + - - -
	8/20	2	72	+ + + -
	8/25	2	24	- - - - -
	8/25	2	48	+ + + - - - -
	8/25	2	72	+ + + - - - -
HEN 34	8/2	2	24	- - - - - - - - - - - - - - -
	8/2	2	48	- - - - - - - - - - - - - - -
	8/2	2	72	- - - - - - - - - - - - - - -
	8/16	2	24	- - - - - - - - - - - - - - -
	8/16	2	48	- - - - - - - - - - - - - - -
	8/16	2	72	- - - - - - - - - - - - - - -
	8/19	2	24	- - - - - -
	8/19	2	48	- - - -
	8/19	2	72	- - - -
	8/20	1	24	- - - - -
	8/20	2	24	- - - -
	8/20	1	48	- - - - -
	8/20	2	48	- - - -
	8/20	1	72	
	8/20	2	72	- - - -
	8/25	2	24	- - - - -
	8/25	2	48	- - - - - - -
	8/25	2	72	- - - - - - -
HEN 464	8/16	2	24	+ + - - - - - - - - - - - - -
	8/16	2	48	+ + - - - - - - - - - - - - -
	8/16	2	72	+ + - - - - - - - - - - - - -
	8/19	2	24	+ + - - - - -
	8/19	2	48	+ + - - - -
	8/19	2	72	+ + - -
	8/20	2	24	+ + - -
	8/22	1	24	+ + + + +
	8/20	2	48	+ + - -
	8/22	1	48	+ + + + +
	8/20	2	72	+ + - -
	8/22	1	72	
	8/25	2	24	- - - - -
	8/25	2	48	+ + - - - - -
	8/25	2	72	+ + - - - - -
HEN 61	8/17	1	24	- - - - - - - - - - - - - - -
	8/19	2	24	+ + - - - - -
	8/17	1	48	+ + + + + + + - - - - - - - -
	8/19	2	48	+ + - - - - - -
	8/17	1	72	
	8/19	2	72	+ + - - - -
	8/20	1	24	
	8/20	2	24	+ + - -
	8/20	1	48	
	8/20	2	48	+ + - - - -
	8/20	1	72	+ + + + -
	8/20	2	72	+ + + - - -
	8/25	2	24	- - - - -
	8/25	2	48	- - - - - - -
	8/25	2	72	- - - - - - +

TABLE 7.

AGGLUTINATION TESTS MADE WITH SERUM REMOVED JULY 3, 1913 AND TEST FLUID COMPOSED OF S_1 S_2 S_3 S_5 S_6 AND S_7	AGGLUTINATION TESTS MADE WITH BLOOD SERUM REMOVED JULY 19, 1913 AND A TEST FLUID COMPOSED OF S_1 S_2 S_3 S_5 S_6 AND S_7
DATE / TECHNICIAN / HOURS / DILUTIONS	DATE / TECHNICIAN / HOURS / DILUTIONS
[illegible]	[illegible]

of this work, the serum was divided into three portions, to serve the technicians for independent work. The period of making tests for one technician often required more time to which the serum was submitted to laboratory temperature than that of another, and this in a way perhaps explains the keeping quality of one portion over another. However, one can see from the tests made that comparatively recently drawn sera carefully retained on ice yielded the best results.

Hens Nos. 315, 49, 60, 22, 77, 4, 35, 618, 46 and 34 never gave a positive reaction during this work, and the work of all three technicians checks in this respect. The serum of Nos. 2096, 52 and 464 gave varying reactions after long retention of serum, but no trouble was experienced by any of the workers in concluding that these birds either were harboring or had harbored *Bacterium pullorum*.

It may be stated here that under the conditions of the tests, if the test fluid is prepared uniformly, the test carefully carried out, the macroscopic agglutination test for detecting the virus of *Bacterium pullorum* has proven a good laboratory method as handled by three laboratory technicians in this laboratory during the past summer.

The Influence of Test Fluids of Varying Composition (Monovalent and Polyvalent Test Fluids).

For these tests an experiment was planned in which the serum was used, drawn on the 19th of July. The test fluid was composed of equal quantities of the different strains of *Bacterium pullorum* used throughout this work. In the first experiment or test a test fluid containing S_1 was used; in the second, a test fluid containing S_2; in a third, a test fluid containing equal quantities S_1 and S_2; in a fourth, a test fluid containing equal quantities S_1, S_2 and S_3; in a fifth, a test fluid containing equal quantities S_1, S_2 and S_7; in a sixth, a test fluid containing S_1, S_2, S_3 and S_5; in a seventh, a test fluid containing S_1, S_2, S_3, S_5 and S_6; and in an eighth, a test fluid containing S_1, S_2, S_3, S_5, S_6 and S_7. Various dilutions of the serum were used, the dilutions being made as before. In most cases readings were made after twenty-four, forty-eight and seventy-two hours' incubation.

An analysis of Table 9 shows that the serum from all hens which had previously agglutinated gave consistent positive results in all the sera. Sera from hens Nos. 2096, 452, 792 and 5 appeared to give better results with a test fluid containing several strains of the organism. Although some of the positive reactors showed good reactions with a monovalent test fluid, yet from the data at hand it may be stated as justified that a test fluid containing several different strains is best suited, under most conditions, in laboratory routine for making the test. Here it should be noted that none of the birds previously tested and found negative reacted when their serum was mixed with the test fluids of the various compositions.

The birds Nos. 58, 59, 62 and 63 were cocks. Of these, 59, 62 and 63 gave questionable reactions, and 58 gave a very weak or slight reaction

of a positive nature. This is interesting, and it will require further study with this blood and work in connection with the autopsies of such birds to determine if the testicles of such individuals harbor the organism. The reactions with these birds were always very slight and questionable, and hardly comparable with the clearcut reactions exhibited when the blood serum from infected hens was used.

Comparison of Results of Macroscopic Agglutination Tests with Egg Analysis.

From the egg record table it can be seen that *Bacterium pullorum* was isolated 32 times from 619 eggs, and the individuals harboring such organisms, determined by eggs laid in July, were hen No. 10 on the 30th; hen No. 18 on the 26th; hen No. 6 on the 16th, 17th and 19th; hen No. 5 on the 30th; hen No. 2 on the 26th and 30th; hen No. 52 on the 21st and 23d; hen No. 13 on the 22d and 26th; hen No. 792 on the 23d, 25th and 30th; hen No. 714 on the 27th; and in August, besides these hens, hen No. 8 laid an egg containing *Bacterium pullorum* on the 18th; hen No. 1 on the 15th; hen No. 2096 on the 12th; hen No. 7 on the 4th and 13th; and in September, hen No. 48 on the 6th; hen No. 464 on the 13th and the 16th. Hen No. 452 died before an egg was laid which contained the organism, but at autopsy, when ova from this individual were crushed and inoculated into sterile bouillon and put in incubator at 38° C., the organism was detected later on the agar streaks. Hen No. 267 had previously been found to be infected by an egg test. Serum from all these hens caused agglutination of *Bacterium pullorum* test fluids, the results of three technicians being in agreement. The organism was not isolated from the ovarian tissue of hen Nos. 53 or 61, although both these hen's blood serum caused very active agglutination. This may suggest that the active infection had passed, and the agglutination test showed the results of the past active infection. On the other hand, hens Nos. 315, 49, 60, 22, 77, 4, 35, 618, 312, 46 and 34 never exhibited the organism in their eggs, nor did blood serum from these individuals cause agglutination of *Bact. pullorum.*

Post-mortem Findings of Some Reactors and Non-reactors.

After Oct. 1, 1913, hens Nos. 10, 5, 52, 1, 792, 464, 6 and 13, as reactors, were killed and the ovaries examined for the presence of *Bacterium pullorum.* All the reactors were not killed because it was desired to make further studies with the agglutinins. At the present time hens containing active agglutinative sera are retained at the laboratory under constant observation. Hen No. 10 at autopsy revealed a pathological ovary containing several retention cysts. *Bacterium pullorum* was isolated from this material by direct inoculation. Hen No. 52 at autopsy showed an ovary with retention cysts, and from material crushed in sterile bouillon *B. pullorum* was detected on all tubes streaked from such material. Then hens Nos. 1, 5, 6, 792, 464 and 13 were autopsied. All ovaries from these

TABLE 9.

AGGLUTINATION TESTS MADE WITH TEST FLUIDS OF DIFFERENT COMPOSITIONS

$S_1 - S_1 S_2 S_3 S_5 S_6 S_7$

TEST FLUID CONTAINS S_1

Hen No.	Hrs.				
267	24	+	-	-	-
	48	+	+	-	-
	72	+	+	-	-
8	24	+	+	+	+
	48	+	+	+	+
	72	+	+	+	+
315	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
1	24	-	-	-	-
	48	+	+	+	+
	72	+	+	+	+
49	24	-	-	-	-
	48	-	-	-	-
	72	+	-	-	-
60	24	-	-	-	-
	48	+	-	-	-
	72	+	-	-	-
22	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
10	24	+	+	+	+
	48	+	+	+	+
	72	+	+	+	+
19	24	-	-	-	-
	48	+	+	+	+
	72	+	+	+	+
77	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
6	24	+	+	+	+
	48	+	+	+	+
	72	+	+	+	+
2096	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
2	24	+	+	+	+
	48	+	+	+	+
	72	+	+	+	+
4	24	+	+	-	-
	48	+	+	-	-
	72	+	+	-	-
35	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
48	24	-	-	-	-
	48	+	-	-	-
	72	+	+	+	+
618	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
7	24	+	+	+	+
	48	+	+	+	+
	72	+	+	+	+
46	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
13	24	+	+	+	+
	48	+	+	+	+
	72	+	+	+	+
53	24	-	-	-	-
	48	+	+	+	+
	72	+	+	+	+
792	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
714	24	+	-	-	-
	48	+	+	-	-
	72	+	+	-	-
34	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
464	24	+	+	-	-
	48	+	+	-	-
	72	+	+	-	-
61	24	+	+	-	-
	48	+	+	-	-
	72	+	+	-	-
58	24	-	-	-	-
	48	+?	-	-	-
	72	+?	-	-	-
59	48	-	-	-	-
	24	-	-	-	-
	72	-	-	-	-
62	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
63	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-

TEST FLUID CONTAINS S_2

Hen No.	Hrs.						
267	24				-	-	-
	48				-	-	-
	72				-	-	-
8	24				+	+	+
	48				+	+	+
	72				+	+	+
315	24		-	-			
	48		-	-			
	72		-	-			
1	24				+	-	-
	48				+	+	-
	72				+	+	+
60	24	-	-	-			
	48	-	-	-			
	72	-	-	-			
10	24				-	-	-
	48				-	-	-
	72				+	-	-
18	24				+	+	-
	48				+	+	+
	72				+	+	-
77	24	-	-	-			
	48	-	-	-			
	72	-	-	-			
6	24				+	-	-
	48				+	-	-
	72				+	+	-
2096	24				-	-	-
	48				-	-	-
	72				-	-	-
5	24		-	-			
	48		-	-			
	72		+	+			
2	24	+	+	+	-	-	-
	48	+	+	+	-	-	-
	72	+	+	+	-	-	-
4	24	-	-	-			
	48	-	-	-			
	72	-	-	-			
35	24	-	-	-			
	48	-	-	-			
	72	-	-	-			
48	24		-	-			
	48		-	-			
	72		-	-			
618	24	-	-	-			
	48	-	-	-			
	72	-	-	-			
7	24	+	+	+	-	-	-
	48	+	+	+	+	-	-
	72	+	+	+	+	+	-
46	24		-	-			
	48		-	-			
	72		-	-			
52	24				-	-	-
	48				-	-	-
	72				-	-	-
13	24	+	+	+	+		
	48	+	+	+	+		
	72	+	+	+	+		
53	24	+	+	+	-	-	-
	48	+	+	+	-	-	-
	72	+	+	+	-	-	-
452	24	+	+	-	-	-	-
	48	+	+	-	-	-	-
	72	+	+	-	-	-	-
792	24				-	-	-
	48				-	-	-
	72				-	-	-
714	24		-	-			
	48		-	-			
	72		-	-			
34	24	-	-	-			
	48	-	-	-			
	72	-	-	-			
464	24	+	+		-	-	-
	48	+	+		-	-	-
	72	+	+		-	-	-

TEST FLUID CONTAINS $S_1 + S_2$

Hen No.	Hrs.	
267	24	+ - - - - - - - - - - - - - - -
	48	+ - - - - - - - - - - - - - - -
	72	+ + - - - - - - - - - - - - - -
8	24	+ + + + + + + + + - - - - - - -
	48	+ + + + + + + + + + + - - - - -
	72	+ + + + + + + + + + - - - - - -
315	24	- - - - - - - - - - - - - - - -
	48	- - - - - - - - - - - - - - - -
1	24	+ + + + + + + - - - - - - - - -
	48	+ + + + + + + + + + + + + + + +
49	24	- - - - - - - - - - - - - - - -
	48	- - - - - - - - - - - - - - - -
	72	- - - - - - - - - - - - - - - -
60	24	- - - - - - - - - - - - - - - -
	48	- - - - - - - - - - - - - - - -
22	24	- - - - - - - - - - - - - - - -
	48	- - - - - - - - - - - - - - - -
	72	- - - - - - - - - - - - - - - -
10	24	+ + + - - - - - - - - - - - - -
	48	+ + + + - - - - - - - - - - - -
	72	+ + + + - - - - - - - - - - - -
18	24	+ + + + + + + + + + + + - - - -
	48	+ + + + + + + + + + + + + + - -
77	24	- - - - - - - - - - - - - - - -
	48	- - - - - - - - - - - - - - - -
6	24	+ + + + + - - - - - - - - - - -
	48	+ + + + + - - - - - - - - - - -
	72	+ + + + + + + + + - - - - - - -
2096	24	- - - - - - - - - - - - - - - -
	48	- - - - - - - - - - - - - - - -
	72	- - - - - - - - - - - - - - - -
2	24	+ + + - - - - - - - - - - - - -
	48	+ + + + + + + - - - - - - - - -
	72	+ + + + + + + + + + - - - - - -
4	24	- - - - - - - - - - - - - - - -
	48	+ + - - - - - - - - - - - - - -
35	24	- - - - - - - - - - - - - - - -
	48	- - - - - - - - - - - - - - - -
48	24	- - - - - - - - - - - - - - - -
	48	+ - - - - - - - - - - - - - - -
	72	+ - - - - - - - - - - - - - - -
618	24	- - - - - - - - - - - - - - - -
	48	- - - - - - - - - - - - - - - -
7	24	+ + + + + + + + + + - - - - - -
	48	+ + + + + + + + + + - - - - - -
	72	+ + + + + + + + + - - - - - - -
46	24	- - - - - - - - - - - - - - - -
	48	- - - - - - - - - - - - - - - -
	72	- - - - - - - - - - - - - - - -
13	24	+ + + + + + - - - - - - - - - -
	48	+ + + + + + - - - - - - - - - -
792	24	- - - - - - - - - - - - - - - -
	48	- - - - - - - - - - - - - - - -
	72	- - - - - - - - - - - - - - - -
714	24	+ - - - - - - - - - - - - - - -
	48	+ - - - - - - - - - - - - - - -
	72	+ - - - - - - - - - - - - - - -
34	24	- - - - - - - - - - - - - - - -
	48	- - - - - - - - - - - - - - - -
	72	- - - - - - - - - - - - - - - -
464	24	+ + - - - - - - - - - - - - - -
	48	+ + - - - - - - - - - - - - - -
	72	+ + - - - - - - - - - - - - - -
61	24	- - - - - - - - - - - - - - - -
	48	+ + + + + + + - - - - - - - - -
58	24	- - - - - - - - - - - - - - - -
	48	- - - - - - - - - - - - - - - -
59	24	- - - - - - - - - - - - - - - -
	48	- - - - - - - - - - - - - - - -
62	24	- - - - - - - - - - - - - - - -
	48	- - - - - - - - - - - - - - - -
63	24	+? +? +? +? - - - - - - - - - - - -
	48	+? +? +? +? +? - - - - - - - - - - -

TEST FLUID CONTAINS $S_1 + S_2 + S_3$

Hen No.	Hrs.					
267	24	+	+			
	72	+	+			
8	24	+	+	+	+	+
	48	+	+	+	+	+
	72	+	+	+	+	+
315	24	-	-	-	-	-
1	24	+	+	+	+	+
	48	+	+	+	+	+
49	24	-	-	-	-	-
	48	+	-	-	-	-
	72	+	+	+	+	-
60	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
22	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
10	24	+	+	+	+	+
	48	+	+	+	+	+
	72	+	+	+	+	+
18	24	+	+	+	+	+
	72	+	+	+	+	+
77	24	-	-	-	-	-
	72	-	-	-	-	-
6	24	+	+	+	+	+
	48	+	+	+	+	+
	72	+	+	+	+	+
2096	24	+	+	-	-	-
	48	+	+	+	-	-
	72	+	+	+	-	-
2	24	+	+	+	+	-
	48	+	+	+	+	-
4	24	+	+	+	-	-
	72	+	+	+	-	-
35	24	-	-	-	-	-
	72	-	-	-	-	-
48	24	+	+	-	-	-
	48	+	+	+	-	-
	72	+	+	+	-	-
618	24	+	-	-	-	-
	72	-	-	-	-	-
7	24	+	+	+	+	+
	48	+	+	+	+	+
	72	+	+	+	+	+
46	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
13	24	+	+	+	+	+
	48	+	+	+	+	+
	72	+	+	+	+	+
13	24	+	+	+	+	+
	48	+	+	+	+	+
792	24	+	+	+	-	-
	48	+	+	+	+	+
	72	+	+	-	-	-
714	24	+	+	+	-	-
	48	+	+	+	-	-
	72	+	+	-	-	-
34	24	-	-	-	-	-
	48	-	-	-	-	-
464	24	+	+	+	+	+
	48	+	+	+	+	+
61	72	+	+	+	+	-
58	24	+	+	-	-	-
	48	+	+	-	-	-
	72	+	+	-	-	-
59	24	-	-	-	-	-
	48	+?	-	-	-	-
	72	+?	-	-	-	-
62	24	+?	+?	+?	+?	-
	48	+?	+?	+?	+?	+
	72	+?	+?	+?	+?	-
63	24	+?	+?	+?	+?	-
	48	+?	+?	+?	+?	-
	72	+?	+?	+?	+?	-

TEST FLUID CONTAINS $S_1 + S_2 + S_7$

Hen No.	Hrs.	
315	24	- - - - - - - - - - - - - - - -
	48	- - - - - - - - - - - - - - - -
49	24	- - - - - - - - - - - - - - - -
	48	- - - - - - - - - - - - - - - -
	72	- - - - - - - - - - - - - - - -
60	24	- - - - - - - - - - - - - - - -
	48	- - - - - - - - - - - - - - - -
22	24	- - - - - - - - - - - - - - - -
	48	- - - - - - - - - - - - - - - -
	72	- - - - - - - - - - - - - - - -
4	24	- - - - - - - - - - - - - - - -
	48	- - - - - - - - - - - - - - - -
35	24	- - - - - - - - - - - - - - - -
	48	- - - - - - - - - - - - - - - -
618	24	- - - - - - - - - - - - - - - -
	48	- - - - - - - - - - - - - - - -
46	24	- - - - - - - - - - - - - - - -
	48	- - - - - - - - - - - - - - - -
34	24	- - - - - - - - - - - - - - - -
	48	- - - - - - - - - - - - - - - -
	72	- - - - - - - - - - - - - - - -

TEST FLUID CONTAINS $S_1 + S_2 + S_3 + S_5$

Hen No.	Hrs.				
267	24	+	-	-	-
	48	+	+	-	-
	72	+	+	+	-
8	24	+	+	+	+
	48	+	+	+	+
	72	+	+	+	+
315	24	-	-	-	-
	48	+	-	-	-
	72	+	-	-	-
1	24	+	+	+	-
	48	+	+	+	+
	72	+	+	+	+
49	24	-	-	-	-
	48	+	-	-	-
	72	+	-	-	-
60	24	-	-	-	-
	48	-	-	-	-
	72	+	-	-	-
22	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
10	24	+	+	+	-
	48	+	+	+	+
	72	+	+	+	+
19	24	+	+	+	+
	48	+	+	+	+
	72	+	+	+	+
77	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
6	24	+	+	-	-
	48	+	+	+	-
	72	+	+	+	+
2096	24	-	-	-	-
	48	-	-	-	-
	72	+	+	+	+
2	24	+	+	+	+
	48	+	+	+	+
	72	+	+	+	+
4	24	+	+	-	-
	48	+	+	-	-
	72	+	+	-	-
35	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
48	24	-	-	-	-
	48	+	-	-	-
	72	+	+	-	-
618	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
7	24	+	+	+	+
	48	+	+	+	+
	72	+	+	+	+
46	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
13	24	+	+	-	-
	48	+	+	+	+
	72	+	+	+	+
53	24	-	-	-	-
	48	+	+	+	+
	72	+	+	+	+
792	24	-	-	-	-
	48	-	-	-	-
	72	+	+	+	-
714	24	+	-	-	-
	48	+	+	-	-
	72	+	+	+	-
34	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
464	24	+	+	-	-
	48	+	+	-	-
	72	+	+	-	-
61	24	+	+	-	-
	48	+	+	-	-
	72	+	+	+	-
58	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
59	24	+?	-	-	-
	48	+?	-	-	-
	72	+?	-	-	-
62	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-
63	24	-	-	-	-
	48	-	-	-	-
	72	-	-	-	-

TEST FLUID CONTAINS $S_1 + S_2 + S_3 + S_5 + S_6$

Hen No.	Hrs.					
267	24	+	-	-		
	48	+	+	-		
	72	+	+	-		
8	24	-	-	-		
	48	+	+	+		
	72	+	+	+		
315	24	-	-	-	-	-
	48	+	-	-	-	-
	72	+	-	-	-	-
1	24	+	+	-		
	48	+	+	+		
	72	+	+	+		
49	24	-	-	-		
	48	-	-	-		
	72	-	-	-		
60	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
22	24	-	-	-		
	48	+	+	-		
	72	+	+	-		
10	24	+	-	-		
	48	+	-	-		
	72	+	+	+		
18	24	+	+	+	+	+
	48	+	+	+	+	+
	72	+	+	+	+	+
77	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
6	24	-	-	-		
	48	+	+	+		
	72	+	+	+		
2096	24	+	+	+		
	48	+	+	+		
	72	+	+	+		
5	24	-	-	-		
	48	+	-	-		
	72	+	+	-		
2	24	-	-	-		
	48	-	-	-		
	72	-	-	-		
4	24	+	+	+	-	-
	48	+	+	+	-	-
	72	+	+	+	-	-
35	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
48	24	-	-	-		
	48	-	-	-		
	72	-	-	-		
618	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
7	24	+	+	+	+	+
	48	+	+	+	+	+
	72	+	+	+	+	+
46	24	-	-	-	-	
	48	-	-	-	-	
	72	-	-	-	-	
13	24	+	+	+		
	48	+	+	+		
	72	+	+	+		
53	24	+	+	+	+	-
	48	+	+	+	+	+
	72	+	+	+	+	+
452	24	-	-	-		
	48	+	-	-		
	72	+	-	-		
792	24	-	-	-		
	48	-	-	-		
	72	+	+	-		
714	24	+	+	-		
	48	+	+	-		
	72	+	+	-		
34	24	-	-	-		
	48	-	-	-		
	72	-	-	-		
464	24	+	+	+		
	48	+	+	+		
	72	+	+	+		
61	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
59	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
63	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-

Hen No.	Hrs.					
267	24	-	-	-	-	-
	48	-	-	-	-	-
	72	+	-	-	-	-
8	24	+	+	+	+	+
	48	+	+	+	+	+
	72	+	+	+	+	+
1	24	+	+	+	+	-
	48	+	+	+	+	+
	72	+	+	+	+	+
49	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
22	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
10	24	+	+	+	+	+
	48	+	+	+	+	+
	72	+	+	+	+	+
6	24	+	+	+	+	+
	48	+	+	+	+	+
	72	+	+	+	+	+
2096	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
2	24	+	+	+	+	+
	48	+	+	+	+	+
	72	+	+	+	+	+
48	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
46	24	-	-	-		
	48	-	-	-		
	72	-	-	-		
13	24	+	+	+	+	+
	48	+	+	+	+	+
	72	+	+	+	+	+
792	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
714	24	-	-	-	-	-
	48	+	+	+	-	-
	72	+	+	+	-	-
34	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
464	24	-	-	-	-	-
	48	+	+	-	-	-
	72	+	+	-	-	-
58	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-
62	24	-	-	-	-	-
	48	-	-	-	-	-
	72	-	-	-	-	-

TEST FLUID CONTAINS $S_1 + S_2 + S_3 + S_5 + S_6 + S_7$

Hen No.	Hrs.	1:100 1:200 1:500	Hen No.	Hrs.	1:100 1:200 1:500	Hen No.	Hrs.	1:100 1:200 1:500	Hen No.	Hrs.	1:100 1:200 1:500	Hen No.	Hrs.	1:100 1:200 1:500	Hen No.	Hrs.	1:100 1:200 1:500	Hen No.	Hrs.	1:100 1:200 1:500	Hen No.	Hrs.	1:100 1:200 1:500
267	24	+ + -	267	72	+ + +	267	48	+ + +	267	24	- - -	267	72	+ + -	267	24	- - -	267	48	- - -	267	72	- - -
	24	+ + -		72	+ + +		48	- - -		24	+ + -		24	- - -		24	- - -		48	- - -		72	- - -
	48	+ + +		24	- - -		72	+ + -		48	+ + -		48	+ + -		24	- - -		48	- - -		72	- - -
	48	+ + +		24	- - -					48	+ + -		72	+ + -									
8	24	- - -	8	72	+ + +	8	48	+ + +	8	24	+ + +	8	72	+ + +	8	24	- - -	8	48	+ + +	8	72	+ + -
	24	- - -		72	+ + +		48	+ + +		24	+ + +		24	+ + +		24	- - -		48	+ + -		72	- - -
	48	+ + +		24	+ + +		72	+ + +		48	+ + +		48	+ + +		24	- - -		48	- - -		72	- - -
	48	+ + +		24	+ + +					48	+ + +		72	+ + +									
315	24	- - -	315	72	- - -	315	24	- - -	315	24	- - -	315	24	- - -	315	48	- - -	315	72	- - -			
	24	- - -		72	- - -		48	- - -		48	- - -		24	- - -		48	- - -		72	- - -			
	48	- - -					72	+ + -		72	- - -		24	- - -		48	- - -		72	- - -			
	48	- - -																					
1	24	+ + -	1	72	+ + +	1	48	+ + +	1	24	+ + +	1	72	+ + +	1	24	+ - -	1	48	+ - -	1	72	+ + -
	24	+ - -		72	+ + +		48	+ + +		48	+ + +		24	+ - -		24	+ - -		48	+ + -		72	+ + +
	48	+ + +		24	+ + -		72	+ + +		48	+ + +		48	+ + +		24	- - -		48	+ + -		72	+ + -
	48	+ + -		24	+ + +		24	+ + +		72	+ + +		72	+ + +									
49	24	- -	49	48	- - -	49	72	- - -	49	48	- - -												
	24	- - -		48	- - -		24	- - -		72	- - -												
60	24	- - -	60	48	- - -	60	24	- - -	60	24	- - -	60	24	- - -	60	48	- - -	60	72	- - -			
	24	- - -		72	- - -		48	- - -		48	- - -		24	- - -		48	- - -		72	- - -			
	48	- - -		72	- - -		72	- - -		72	- - -		24	- - -		48	- - -		72	- - -			
22	24	- - -	22	48	- - -	22	72	+ + -	22	48	- - -												
	24	- - -		48	- - -		24	- - -		72	- - -												
10	24	+ + -	10	72	+ + +	10	48	+ + +	10	24	+ + +	10	72	+ + +	10	72	+ + +	10	48	- - -	10	72	- - -
	24	+ + -		72	+ + +		48	+ + +		24	+ + +		72	+ + +		24	- - -		48	- - -		72	- - -
	48	+ + +		24	+ + -		72	+ + +		48	+ + +		24	- - -		24	- - -		48	- - -		72	- - -
	48	+ + +		24	+ + +					48	+ + +		48	+ - -		24	- - -						
18	24	+ + +	18	48	+ + +	18	24	+ + +	18	48	+ + +	18	24	+ - -	18	24	+ - -	18	48	- - -	18	72	- - -
	24	+ + +		48	+ + +		24	- - -		72	+ + +		48	+ + -		24	+ + -		48	+ + -		72	+ + -
				72	+ + +		48	+ + +		72	+ + +		72	+ + +		24	+ - -		48	+ - -		72	+ - -
77	24	- - -	77	48	- - -	77	24	- - -	77	24	- - -	77	24	- - -	77	48	- - -	77	72	- - -			
	24	- - -		72	- - -		48	- - -		48	- - -		24	- - -		48	- - -		72	- - -			
	48	- - -		72	- - -		72	- - -		72	- - -		24	- - -		48	- - -		72	- - -			
6	24	- - -	6	48	+ + +	6	24	+ + -	6	48	+ + +	6	24	+ + -	6	24	+ + +	6	48	+ + +			
	24	- - -		72	+ + +		24	+ + -		48	+ + +		48	+ + -		24	+ + +		72	+ + +			
	48	+ + -		72	+ + +		48	+ + +		72	+ + +		72	+ + +		48	+ + +		72	+ + +			
2096	24	+ + -	2096	72	+ + +	2096	48	+ + -	2096	24	- - -	2096	72	+ + -	2096	24	- - -	2096	48	- - -	2096	72	- - -
	24	+ + -		72	+ + +		48	+ + -		24	+ + +		24	- - -		24	- - -		48	- - -		72	- - -
	48	+ + -		24	+ + -		72	+ - -		48	- - -		48	- - -		24	- - -		48	- - -		72	- - -
	48	+ + -		24	- - -		72	+ + +		48	+ + +		72	- - -									
5	24	- - -	5	48	- - -	5	24	+ - -	5	48	- - -	5	24	- - -	5	24	+ - -	5	24	- - -	5	48	- - -
	24	- - -		48	- - -		24	- - -		72	+ + -		48	- - -		48	+ + -		24	- - -		72	- - -
				72	- - -		48	+ + -		72	- - -		72	+ + -		72	- - -		48	- - -		72	- - -
																24	- - -		48	- - -		72	- - -
2	24	- - -	2	72	+ + +	2	48	+ + -	2	24	+ + -	2	72	+ + -	2	24	+ + -	2	48	+ + -	2	72	+ + +
	24	- - -		72	+ + +		48	+ + +		24	+ + -		24	- - -		24	+ + -		48	+ + -		72	+ + +
	48	- - -		24	+ - -		72	+ + +		48	+ + +		48	+ - -		24	+ + +		48	+ + -		72	+ + +
	48	- - -		24	+ + -		72	+ + +		48	+ + +		72	+ + +									
4	24	- - -	4	48	- - -	4	24	- - -	4	24	- - -	4	24	- - -	4	48	- - -	4	72	- - -			
	24	- - -		72	- - -		48	- - -		48	- - -		24	- - -		48	- - -		72	- - -			
	48	- - -		72	- - -		72	- - -		72	- - -		24	- - -		48	- - -		72	- - -			
35	24	- - -	35	48	- - -	35	24	- - -	35	48	- - -	35	24	- - -	35	24	- - -	35	48	+ + -	35	72	- - -
	24	- - -		72	- - -		24	+ + -		72	+ + -		48	- - -		24	- - -		48	- - -		72	- - -
	48	- - -		72			48	- - -		72	- - -		72	- - -		24	- - -		48	- - -		72	- - -
48	24	- - -	48	72	+ + +	48	48	- - -	48	24	- - -	48	72	+ - -	48	24	+ + -	48	48	+ + -	48	72	+ + -
	24	- - -		72	+ + +		48	+ - -		24	- - -		24	+ + -		24	+ + -		48	+ + -		72	+ + -
	48	- - -		24	- - -		72	+ + -		48	+ + +		48	+ + -		24	+ + -		48	+ + +		72	+ + +
	48	- - -		24	- - -		72	+ + -		48	- - -		72	+ + -									
618	24	- - -	618	72	- - -	618	24	- - -	618	24	- - -	618	24	- - -	618	24	- - -	618	48	- - -	618	72	- - -
	24	- - -		24	- - -		48	- - -		48	- - -		48	- - -		24	- - -		48	- - -		72	- - -
	48	- - -		48	- - -		72	- - -		72	- - -		72	- - -		24	- - -		48	- - -		72	- - -
	48	- - -		72	- - -																		
7	24	- - -	7	72	+ + +	7	48	+ + +	7	24	+ + +	7	72	+ + +	7	24	+ + +	7	48	+ + +	7	72	+ + +
	24	- - -		72	+ + +		48	+ + +		24	+ - -		24			24	+ + +		48	+ + +		72	+ + +
	48	+ + +		24	+ + -		72	+ + +		48	+ + +		48	+ + +		24	+ + +		48	+ + +		72	+ + +
	48	+ + +		24			72	+ + +		48	+ + -		72	+ + +									
46	24	- - -	46	72	+ - -	46	48	- - -	46	24	+ - -	46	24	- - -	46	24	- - -	46	48	- - -	46	72	- - -
	24	- - -		24	- - -		72	- - -		48	- - -		48	- - -		24	- - -		48	- - -		72	- - -
	48	- - -		24	- - -		72	- - -		72	+ - -		72	- - -		24	- - -		48	- - -		72	- - -
	48	+ - -		48	- - -																		
52	24		52	48	- - -	52	24	+ + -	52	24	- - -	52	24	- - -	52	48	- - -	52	72	- - -			
	24	- - -		72	+ + -		48	+ + -		48	- - -		24	- - -		48	- - -		72	- - -			
	48	- - -		72	- - -		72	+ + +		72	- - -		24	- - -		48	- - -		72	- - -			
13	24	- - -	13	72	+ + -	13	48	+ + +	13	24	+ - -	13	72	+ + +	13	24	+ + -	13	48	+ + -	13	72	+ + -
	24	- - -		72	+ + -		48	+ + -		24	+ + +		24	+ + -		24	+ + -		48	+ + -		72	+ + -
	48	- - -		24	+ + -		72	+ + -		48	+ + +		48	+ + +		24	+ + -		48	+ + -		72	+ - -
	48	+ - -		24	- - -		72	+ + -		48	+ + -		72	+ + -									
53	24	+ - -	53	48	+ + +	53	24	+ + -	53	48	+ + +	53	24	+ -	53	24	+ - -	53	48	+ + -	53	72	+ + +
	24	+ - -		72	+ + +		24	+ - -		72	+ + +		48	+ + -		24	+ + -		48	+ + -		72	+ + +
	48	+ + -		72	+ + +		48	+ + +		72	+ + +		72	+ + -		24	+ + -		48	+ + -		72	+ + +
452	24	+ + +	452	72	+ + +	452	48	- - -	452	24	- - -	452	72	+ + -	452	24	+ + -	452	48	+ + -	452	72	+ + -
	24	+ + -		72	+ + +		48	- - -		24	+ + +		24	+ + -		24	+ + -		48	+ + -		72	+ + -
	48	+ + +		24	- - -		72	+ - -		48	+ + +		48	+ + -		24	+ + -		48	+ + -		72	+ + -
	48	+ + +		24	- - -		72	+ + +		48	+ + -		72	+ - -									
792	24	+ + -	792	72	+ + -	792	48	- - -	792	24	- - -	792	72	+ - -	792	24	- - -	792	48	- - -	792	72	- - -
	48	+ + -		72	+ + +		48	- - -		24	- - -		24	- - -		24	- - -		48	- - -		72	- - -
	24	+ + +		24	- - -		72	+ - -		48	+ + +		48	- - -		24	- - -		48	- - -		72	- - -
	48	+ + +		24	- - -		72	+ + -		48	- - -		72	- - -									
464	24	+ + -	464	48	+ + +	464	24	+ + -	464	48	+ - -	464	24	+ + -	464	48	+ + +	464	48	- - -	464	24	- - -
	24	+ + +		72	+ + +		24	+ - -		72	+ + -		24	+ + +		72	+ + +		72	+ - -		48	+ - -
	48	+ + +		72	+ + -		48	+ + -		72	+ + -		48	+ + +		24	- - -		24	- - -		48	+ - -

hens were cystic, exhibiting cysts of varying sizes, and the color was from normal yellow to grayish green. Hen No. 5 showed the least pathological condition of the ovaries. Many ova here were quite normal, and exhibited the usual high-colored picture so characteristic of a healthy ovary. Material from hens Nos. 1, 5, 6, 792, 464, 13 and 452 (previously examined) yielded cultures of *Bacterium pullorum.* Hens Nos. 34, 315, 49, 312, 60, 22, 77, 4, 35, 618 and 46, whose sera had never agglutinated, and in whose eggs *Bacterium pullorum* had not been found, were autopsied. All ova were normal except that of 77, which showed grossly congestion. More than 100 agar tubes were streaked from these ovaries and from materials crushed in sterile bouillon and incubated, and all gave negative results for *B. pullorum.* Hen No. 53, a positive reactor, and hen No. 46, a non-reactor, were killed accidentally, so data on ovaries from these hens were not obtained. The pathological findings of the birds that agglutinated correspond well with those previously described, and especially with previous observations by the author in 1910,[1] and also substantiate the work of Jones.[2] All ovaries from these birds exhibited one or more retention cysts and several irregular lobulated cysts, and the color varied from shades of yellow to green.

Specificity of Bacterium Pullorum Agglutinin.

The first recognition of the agglutination reaction as a separate function of immune sera was by Gruber and Durham.[3] From the first these investigators had claimed specificity for the agglutination reaction, and for this reason it was utilized by Widal for the diagnosis of typhoid fever. Even by early workers it was observed that serum of animals immunized against one micro-organism would often agglutinate to a much less marked degree other closely related species. The serum of a typhoid-immune animal may agglutinate the typhoid bacillus in dilutions of 1–1,000 and higher, and *B. coli* in dilutions as high as 1–200. The normal agglutinative power of *B. coli* does not exceed 1–20. Therefore the specificity of the reaction for practical purposes is not destroyed if the proper dilutions are carried out, the degree or amount of agglutinin formation being always far higher for the specific organism causing the formation of the agglutinin than for closely related species.

After carrying out 300 tests with normal sera from birds known to have no infection, we feel justified in stating that in some instances we were able to obtain slight agglutinative reactions in dilutions of 1–25, but in no instance was there ever exhibited the slightest sign of the agglutination of *Bacterium pullorum* when dilutions 1–100 of normal serum from non-

[1] Gage, Geo. Edward: "Notes on ovarian infection with *Bacterium pullorum* (Rettger) in the domestic fowl." Journal Medical Research, Vol. XXIV., No. 3; N. S., Vol. XIX., No. 3; June, 1911, pp. 491–496.

[2] Jones, F. S.: "The value of the macroscopic agglutination test in detecting fowls that are harboring *Bact. pullorum.*" Journal Medical Research, Vol. XXVII., No. 4; N. S., Vol. XXII., No. 4, pp. 485-495.

[3] Gruber and Durham: Münch med. Woch, 1906.

infected individuals were used. For this reason, in the work carried out here, the lowest diagnostic dilution was 1–100. If reaction resulted with *Bacterium pullorum* in this dilution it was considered positive, and the individual rated as a reactor.

Since *Bacterium pullorum* has been placed in the *B. coli-typhi-dysenteræ* group of bacteria it was considered of interest to determine if *Bacterium pullorum* agglutinative sera were specific for *Bacterium pullorum.* For these tests the best known members of the *B. coli-typhi* group of bacteria were used. The sera from two hens harboring the organism was drawn and diluted with carbolated salt solution 1–20. Test fluids of uniform turbidity were prepared, as previously for *Bacterium pullorum,* of the following organisms: *B. coli communis, B. coli communior, B. icteroides, B. enteritidis, B. paratyphi A., B. paratyphi B., B. typhi abdominalis, B. Fowl cholera, B. cloacæ, B. lactis acrogenes,* and lastly a test fluid of *Bacterium pullorum.* Complete sets of test tubes were made for each, and to each was added the amount of *Bacterium pullorum* agglutinative sera to give the required dilution. The dilutions in all sets were from 1–100 to 1–5,000, the principal dilutions between these ranges were in the following order: 1–100, 1–200, 1–300, 1–400, 1–500, 1–800, 1–1,000, 1–1,200, 1–1,500, 1–1,800, 1–2,000, 1–2,500, 1–3,000, 1–4,000 and 1–5,000.

By observation of Table 10 it can be seen that the *Bacterium pullorum* agglutinative sera caused agglutination only when put in contact with *Bacterium pullorum.* Not the slightest agglutination occurred in any of the tubes containing test fluid other than *Bacterium pullorum.* From this data it would seem that the *Bacterium pullorum* agglutinin is highly specific, and therefore is of great diagnostic value in all work in which the organism must be determined.

Agglutinins obtained by the Immunization of Rabbits against Bacterium Pullorum.

Rabbits are easily infected with *Bacterium pullorum,* or at least show a marked reaction when injected with pure cultures of this organism; but by a careful procedure of immunization they yield very active agglutinins and also bacteriolytic sera. From 100 tests made in this laboratory it has been found that these agglutinins elaborated in this way are much more stable than those from individuals harboring the organism. Rabbits retained in this laboratory at the present time furnish sera which were active in dilutions up to 1–5,000. Agglutinins in such sera have aided greatly in the diagnosis or differentiation of cultures of *Bacterium pullorum.*

Summary.

From the work carried out at this laboratory during the summer of 1913, the following conclusions appear to be justifiable: —

1. Although the egg test for the determination of *Bacterium pullorum* may yield positive results showing ovarian infection, the elimination is

TABLE 10.

TABLE SHOWING SPECIFICITY OF BACTERIUM PULLORUM AGGLUTININ

HEN No.	HRS.	1-100	1-200	1-300	1-400	1-500	1-800	1-1000	1-1200	1-1500	1-1800	1-2000	1-2500	1-3000	1-4000	1-5000
B. COLI COMMUNIS TEST FLUID + B. PULLORUM AGGLUTININ																
A	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. COLI COMMUNIOR TEST FLUID + B. PULLORUM AGGLUTININ																
A	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. ICTEROIDES TEST FLUID + B. PULLORUM AGGLUTININ																
A	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. ENTERITIDIS TEST FLUID + B PULLORUM AGGLUTININ																
A	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. PARATYPHI. A TEST FLUID + B. PULLORUM AGGLUTININ																
A	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. PARATYPHI. B. TEST FLUID + B. PULLORUM AGGLUTININ																
A	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. TYPHI ABDOMINALIS TEST FLUID + B PULLORUM AGGLUTININ																
A	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. FOWL CHOLERA TEST FLUID + B. PULLORUM AGGLUTININ																
A	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. CLOACAE TEST FLUID + B. PULLORUM AGGLUTININ																
A	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. LACTIS AEROGENES TEST FLUID + B. PULLORUM AGGLUTININ																
A	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. PULLORUM TEST FLUID + B. PULLORUM AGGLUTININ																
A	24	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-
	48	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-
	72	+	+	+	+	+	+	+	+	+	+	+	+	-	-	-

HEN No.	HRS.	1-100	1-200	1-300	1-400	1-500	1-800	1-1000	1-1200	1-1500	1-1800	1-2000	1-2500	1-3000	1-4000	1-5000
B. COLI COMMUNIS TEST FLUID + B. PULLORUM AGGLUTININ																
BB	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. COLI COMMUNIOR TEST FLUID + B. PULLORUM AGGLUTININ																
B	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. ICTEROIDES TEST FLUID + B. PULLORUM AGGLUTININ																
B	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. ENTERITIDIS TEST FLUID + B PULLORUM AGGLUTININ																
B	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. PARATYPHI A TEST FLUID + B. PULLORUM AGGLUTININ																
B	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. PARATYPHI. B. TEST FLUID + B. PULLORUM AGGLUTININ																
B	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. TYPHI. ABDOMINALIS TEST FLUID + B. PULLORUM AGGLUTININ																
B	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. FOWL CHOLERA TEST FLUID + B. PULLORUM AGGLUTININ																
B	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. CLOACAE TEST FLUID + B. PULLORUM AGGLUTININ																
B	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. LACTIS AEROGENES TEST FLUID + B. PULLORUM AGGLUTININ																
B	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. PULLORUM TEST FLUID + B. PULLORUM AGGLUTININ.																
B	24	+	+	+	+	+	+	+	+	+	+	+	+	+	-	-
	48	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-
	72	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-

irregular and very often covers a long period of time before the organism is detected; therefore it is impractical for rapid diagnosis.

2. Preliminary incubation of the eggs in a bacteriological incubator at 38° to 39° C. prior to testing aids in the determination of the organism.

3. The macroscopic agglutination test as carried out in this laboratory, has proven a good laboratory method for the detection of adult hens harboring, or which have harbored, *Bacterium pullorum.*

4. Our work substantiates that of Jones, in that it is possible to cause a local infection of the ovarian tissue by intravenous injections of pure cultures of *Bacterium pullorum.*

5. The agglutinin is very stable, withstanding temperatures of 60° C. and over for one-half hour. If properly preserved, it will yield results after two weeks. Agglutinins have been found from infected hens which reacted positively in dilutions from 1–100 to 1–5,000.

6. Polyvalent test fluids yield more uniform results than monovalent fluids, although in birds of marked infection monovalent test fluids gave very good results. Test fluids if properly preserved on ice will keep in a very active state for more than two months.

7. Rabbits react to injections with pure cultures of *Bacterium pullorum,* but by careful immunization yield very active agglutinins and also bacteriolytic sera. Agglutinins produced by immunizing rabbits are much more stable than those from hens harboring the organism.

8. A striking pathological condition found in the ovaries of all birds was the exhibition of lobulated and retention cysts which varied greatly in size. From these, it was usually easy to isolate *B. pullorum.*

Acknowledgment. — Thanks are due my sister, Ethel G. Gage, for careful work in connection with calculation and rearrangement of the scientific data from our card-indexing system.

A STUDY OF VARIATION IN APPLES.

J. K. SHAW.

Beginning with the crop of 1908 the apples borne by certain Ben Davis and Baldwin apple trees growing in the college orchard have been measured, both their transverse and longitudinal diameters being taken, and this has been continued up to and including the crop of 1913. This period includes six successive seasons in each of which the Ben Davis trees have borne at least a moderate crop, but the Baldwins have shown some irregularities in bearing. This method has given opportunity for the study of the number of apples borne, the size of the apples and the index of form. Inasmuch as the fruit of each tree has been divided into four lots by bisecting the tree with one plane perpendicular and extending east and west, and with another, horizontal, and about midway of the head of the tree, we have further the opportunity of comparing these factors for what we have called the upper south, lower south, upper north and lower north portions of the trees. Two partial reports of the observations on these trees have been made. For a statement of the method used the reader may be referred to these earlier reports.[1] The present paper reports results to date, and is probably final for this phase of the problem.

The Productiveness of the Trees.

We are not aware of any published data giving the number of apples borne by individual trees for a number of consecutive years. Several have reported the measured quantities produced over a considerable period, and these records have shown marked differences in yield of individual trees. Macoun gives the total yield for several varieties. These figures are taken from his report.[2]

Variety.	Age of Trees (Years).	Years of Bearing.	Number of Trees.	Yields (Gallons).		
				Lowest.	Highest.	Average.
Wealthy, ...	15	12	14	57.0	203.0	113.5
McMahon, ...	23	13	8	226.0	889.0	604.4
McIntosh, ...	21	13	2	367.5	761.0	564.0
Patten, ...	19	13	5	291.5	597.5	406.1

[1] Repts. Mass. Expt. Station: 22, Pt. I. (1910), p. 194; 23, Pt. I. (1911), p. 177.
[2] Rept. Central Expt. Farm., 1910-11, p. 118.

The trees on which our observations have been made are eighteen years old, and all are in a healthy, thrifty condition. All have been given the usual orchard care as to pruning and spraying; all were cared for under the cultivation and cover-crop system until August, 1911, when the Baldwin plot was seeded to grass and clover. The trees are similar in size and vigor, though there is some correlation between size and productiveness in the Ben Davis. Tree No. 8 which has produced the most apples is somewhat larger than any of the other trees. The yields of the trees for the period under observation are as follows: —

	1908.	1909.	1910.	1911.	1912.	1913.	Totals.
Tree No. 2, Ben Davis, .	864	251	425	2,453	724	830	5,547
Tree No. 3, Ben Davis, .	567	343	449	1,576	641	966	4,542
Tree No. 5, Ben Davis, .	469	155	360	1,469	354	1,264	4,071
Tree No. 7, Ben Davis, .	423	431	587	1,278	837	1,010	4,566
Tree No. 8, Ben Davis, .	-	686	1,093	2,249	629	1,611	6,268

	1908.	1909.	1910.	1911.	1912.	1913.	Totals.
Tree No. 2, Baldwin, . .	-	321	287	None.	319	None.	927
Tree No. 4, Baldwin, . .	-	621	189	1,541	None.	495	2,846
Tree No. 5, Baldwin, . .	-	319	546	253	830	None.	1,948

The differences in yield between the several trees are not as great as those reported by Macoun, especially in the Ben Davis, which is one of the most regular and abundant bearers. There is little indication of the biennial bearing habit in the Ben Davis, while the Baldwins show it clearly in later years, though they all bore a crop in both 1909 and 1910. No satisfactory reason for these annual fluctuations in crop can be assigned, but it presumably lies largely in weather conditions at the blossoming season, various conditions influencing the number of fruit buds formed during the previous season, and possibly in some degree to insects and disease. The Ben Davis has blossomed freely each year, while the Baldwins have in off years failed to blossom.

Considering for a moment the yields from the different parts of the trees, divided as has been already explained, we find some slight variations of interest. The numbers of apples have been as follows: —

	Upper South.	Lower South.	Upper North.	Lower North.
1908,	518	714	414	676
1909,	552	379	305	287
1910,	707	893	576	869
1911,	2,082	2,111	2,310	2,522
1912,	791	501	677	380
1913,	1,550	1,432	1,393	1,306
Totals,	6,200	6,030	5,675	6,040

These figures are for the Ben Davis trees only, as the Baldwins have been so irregular in bearing as to seriously interfere with any significance that the figures might otherwise have. The upper south quarters of the trees have borne the greatest number of apples, and the annual fluctuations have been least. However, the difference is not great enough to have much significance. So far as it goes it is in accordance with the reasonable supposition that that part of the tree most exposed to the warmth and light of the sun sets the largest number of fruits. As will be shown later the upper south part of the trees have yielded larger apples as well as a few more, so that the yield in barrels should be sensibly greater. If this is true of the parts of the tree, may it not indicate that a southern slope will yield more than a northern one? Probably such an assumption would be hardly justified, especially as the increased size may not hold generally. Also there have doubtless been small variations in the division of the trees from year to year, but these would tend to offset each other when the whole period is considered. Warren,[1] found in Wayne County, N. Y., the highest yields on easterly slopes, while Martin, found in Ontario County that the largest yields were from orchards on level sites followed by those on north, east and west slopes in the order given.[2]

Size.

The measurements of the greatest cross diameter seem to reveal significant differences in the size of the apples in both individual trees and different parts of the tree. Of the several Ben Davis trees No. 7 has borne the largest apples, 72.92 millimeters, and No. 3 the smallest, 69.99 millimeters; and there has been a fair degree of consistency in the sizes from year to year, No. 7 not having fallen below third place in any one year, and No. 3 having risen above fourth place only once. The other three trees have shown greater fluctuation from year to year, all having occupied both first and last places in the course of the six years of observation, and the differences in averages are not large. The few figures available for the Baldwins are greater and are consistent from year to year. Tree

[1] Cornell Bull. 226, p. 326. [2] Cornell Bull. 307, p. 107.

No. 2 has borne the largest apples and tree No. 4 the smallest, with tree No. 5 intermediate each year. The apples on tree No. 4 were much smaller in 1913 than ever before, due possibly to the previous seeding down to grass and clover.

It seems fair to conclude that individual trees may show a fairly constant tendency from year to year to produce apples larger or smaller than the general average of the orchard.

The extreme difference in average size between the individual trees amounts to a trifle less than 3 millimeters, while between the different parts of the trees it is 2.38 millimeters; but from year to year the differences are more consistent. The apples from the upper south part of the trees have been the largest every year. Those from the upper north part have been second every year except 1911, while the lower north apples have been smallest in four years out of six. This would seem to warrant the conclusion that for the variety the better the exposure of the trees to the sun the larger the growth that may be secured.

The figures for the Baldwins are too fragmentary to be of much value, but so far as they go, while not quite as consistent as those of the Ben Davis, they show the same general tendency. In 1909 the different parts were in the same order as the average of the Ben Davis, while in 1912 the upper north led, followed by the upper south, lower north and lower south.

Considering the average size of the total apples from the Ben Davis trees in the several years we note that they were largest in 1910 and smallest in 1911, the difference between the extremes being 4.04 millimeters. The small size in 1911 is undoubtedly due to the heavy crop borne, but it is significant that this is the only year in which the trees have borne enough to affect the size. There is no relation between size of apples and the number borne until the crop reaches what may be fairly termed a full crop. Probably there is more danger of breaking down the tree than of any serious deficiency in size, provided the trees are well cared for. In 1909 the apples average 90 millimeters in diameter, nearly as small as in 1911. The probable explanation of this is the low temperature prevailing, the March–October mean being the lowest of any of the six years under consideration. There are some further indications of a relationship between the warmth of the season and the size of the apples, but all the fluctuations in size cannot be thus accounted for. We have been unable to trace any relationship whatever between precipitation and size. One possible influence of fertilization is in the case of the crop of 1910, the large size of which may be due to a previous application of lime.

While there is evidence that there has been some relation between mean summer temperature and size it does not appear that the slight variations that have occurred have exercised a controlling influence on the size of the apples. In earlier work along this line a greater effect of temperature was observed, but mostly from stations further north, where seasonal fluctuations of temperature are greater.

A study of the variability in size of the apples from the different trees shows small differences that apparently have some meaning. Those from tree No. 7 are quite consistently the most variable of any, and these have been the largest; there seems to be a possible relationship between size and variability, — the larger the apples the more variable.

As between the apples from different parts of the tree, this relationship does not hold. The apples from the upper south parts of the trees are largest and least variable, and probably the slight differences in variability that occur are simply chance fluctuations.

TABLE 1.—*Size of Apples.*

Ben Davis.

INDIVIDUAL TREES.

Tree No. 2.

[Millimeters.]

YEAR.	Mean.	Standard Deviation.	Coefficient of Variability.
1908,	71.02±.14	6.16±.10	8.67±.14
1909,	70.89±.22	5.40±.16	7.62±.18
1910,	73.15±.19	5.69±.13	7.78±.15
1911,	69.15±.07	5.15±.05	7.45±.07
1912,	71.01±.18	6.68±.12	9.41±.17
1913,	75.63±.16	5.43±.09	7.18±.12
Average,	71.81	5.75	8.02

Tree No. 3.

YEAR.	Mean.	Standard Deviation.	Coefficient of Variability.
1908,	68.80±.15	5.31±.11	7.72±.16
1909,	68.48±.19	5.24±.13	7.65±.22
1910,	72.27±.19	6.01±.13	8.32±.22
1911,	69.14±.07	4.11±.05	5.94±.07
1912,	71.71±.15	5.60±.11	7.81±.15
1913,	69.54±.09	4.90±.08	7.04±.06
Average,	69.99	5.20	7.41

Tree No. 5.

YEAR.	Mean.	Standard Deviation.	Coefficient of Variability.
1908,	68.35±.13	5.55±.08	8.12±.13
1909,	68.32±.27	4.96±.18	7.26±.33
1910,	75.53±.21	5.88±.15	8.00±.22
1911,	70.16±.09	5.29±.07	7.55±.09
1912,	74.01±.25	7.08±.18	9.57±.24
1913,	71.69±.13	4.85±.07	6.76±.09
Average,	71.34	5.70	8.02

TABLE 1. — *Size of Apples* — Continued.

Tree No. 7.

[Millimeters.]

Year.	Mean.	Standard Deviation.	Coefficient of Variability.
1908,	72.80±.18	6 45±.13	8.86±.17
1909,	70.37±.17	5.12±.12	7.28±.19
1910,	75.12±.19	6.85±.14	9.12±.21
1911,	72.69±.11	6.11±.08	8.41±.11
1912,	72.57±.15	6.33±.10	8.72±.14
1913,	73.97±.12	5.69±.09	7.70±.12
Average,	72.92	6.09	8.35
Tree No. 8.			
1909,	70.45±.13	4.93±.09	7.00±.13
1910,	72.57±.09	6.16±.06	8.52±.10
1911,	67.12±.08	5.71±.06	8.50±.09
1912,	73.39±.16	5.79±.11	7.90±.15
1913,	71.93±.09	5.48±.09	7.62±.13
Average,	71.69	5.60	7.82
PARTS OF THE TREES.			
Upper South.			
1908,	70.93±.18	6.40±.13	9.02±.19
1909,	70.96±.14	4.77±.10	6.72±.14
1910,	74.53±.12	4.67±.08	6.27±.11
1911,	70.79±.08	5.66±.06	8.00±.08
1912,	74.34±.13	5.41±.09	7.27±.12
1913,	73.08±.10	5.40±.07	7.39±.09
Average,	72.44	5.38	7.45
Lower South.			
1908,	69.24±.14	5.68±.10	8.20±.14
1909,	69.77±.18	5.06±.12	7.24±.18
1910,	72.87±.14	6.33±.10	8.68±.14
1911,	69.86±.08	5.46±.06	7.81±.11
1912,	70.76±.22	7.28±.16	10.29±.22
1913,	71.45±.09	5.27±.07	7.38±.09
Average,	70.66	5.86	8.27

TABLE 1.—*Size of Apples*—Continued.

Upper North.

[Millimeters.]

Year.	Mean.	Standard Deviation.	Coefficient of Variability.
1908,	71.27±.20	6.14±.15	8.47±.19
1909,	70.86±.20	5.27±.13	7.44±.19
1910,	73.94±.21	6.51±.14	8.80±.19
1911,	69.09±.08	5.65±.06	8.17±.08
1912,	72.37±.15	6.02±.11	8.31±.15
1913,	72.84±.10	5.41±.05	7.43±.09
Average,	71.73	5.83	8.10

Lower North.

Year.	Mean.	Standard Deviation.	Coefficient of Variability.
1908,	69.79±.12	4.96±.08	7.11±.12
1909,	69.40±	5.04±	7.26±
1910,	72.32±.14	6.06±.10	8.38±.14
1911,	67.57±.07	5.55±.05	8.21±.08
1912,	70.84±.21	5.93±.15	8.37±.21
1913,	70.43±.09	5.07±.09	7.19±.08
Average,	70.06	5.43	7.75

TOTAL APPLES.

Year.	Mean.	Standard Deviation.	Coefficient of Variability.
1908,	70.23±.08	5.95±.06	8.47±.08
1909,	70.00±.08	5.11±.06	7.30±.08
1910,	73.27±.08	6.28±.06	8.57±.08
1911,	69.23±.04	5.70±.03	8.24±.04
1912,	72.42±.08	6.31±.05	8.71±.07
1913,	73.19±.05	5.44±.03	7.44±.05

Baldwins.

INDIVIDUAL TREES.

Tree No. 2.

Year.	Mean.	Standard Deviation.	Coefficient of Variability.
1909,	78.62±.21	5.59±.15	7.11±.23
1910,	80.22±.23	5.41±.16	6.74±.27
1912,	79.20±.23	6.05±.16	7.64±.20

TABLE 1. — *Size of Apples* — Concluded.

Tree No. 4.

[Millimeters.]

Year.	Mean.	Standard Deviation.	Coefficient of Variability.
1909, ...	74.39±.14	5.01±.10	6.73±.15
1910, ...	76.90±.27	5.57±.19	7.24±.30
1911, ...	71.78±.08	4.58±.06	6.38±.06
1913, ...	66.91±.20	6.52±.15	9.74±.22
Tree No. 5.			
1909, ...	77.66±.21	5.66±.15	7.29±.22
1910, ...	77.71±.15	5.20±.11	6.69±.15
1911, ...	78.05±.26	6.07±.18	7.78±.23
1912, ...	74.16±.12	5.19±.08	7.00±.11
PARTS OF THE TREES. *Upper South.*			
1909, ...	76.91±.18	5.61±.12	7.29±.16
1912, ...	77.50±.22	5.47±.16	7.06±.20
Lower South.			
1909, ...	76.31±.23	5.83±.16	7.64±.21
1912, ...	73.02±.23	6.11±.17	8.36±.23
Upper North.			
1909, ...	76.34±.20	5.47±.14	7.19±.19
1912, ...	77.96±.21	5.41±.15	6.94±.19
Lower North.			
1909, ...	74.58±.26	5.14±.18	6.89±.25
1912, ...	74.86±.22	5.58±.16	7.45±.21
TOTAL APPLES.			
1909, ...	76.29±.11	5.68±.08	7.45±.10
1910, ...	77.99±.11	5.55±.08	7.12±.10

Form.

The main purpose of this work has been the study of the variation in form of the apples and the causes thereof. The continuation of our observation has resulted in the accumulation of data that confirm earlier conclusions[1] and afford basis for some further deductions concerning the problem.

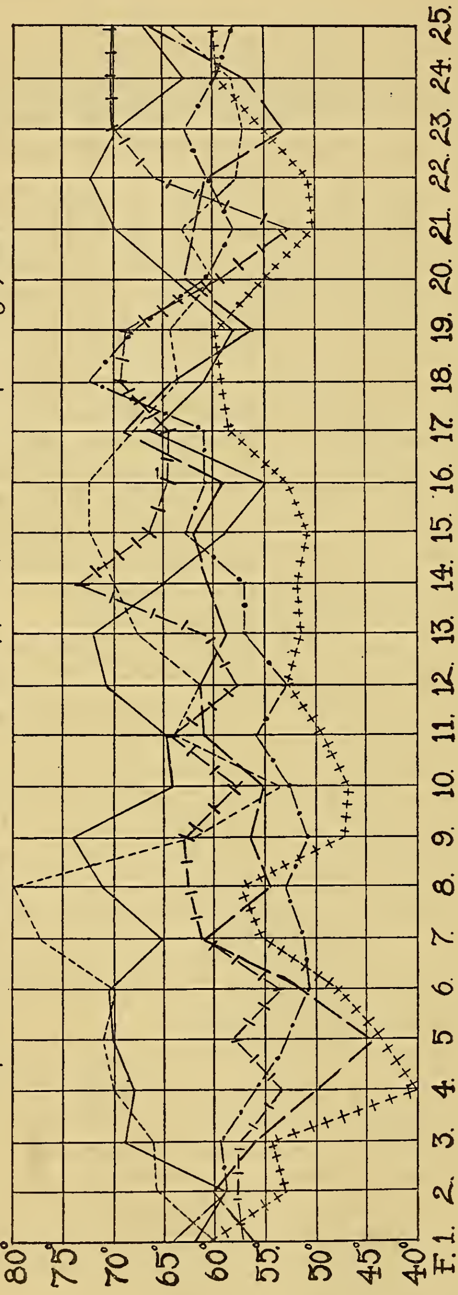
Ben Davis tree No. 7 which has borne the largest apples has also borne the most flattened of any, while the most elongated have been from tree No. 8 closely followed by tree No. 2. The mean indexes of form from year to year have also been fairly consistent, No. 7 ranking first four times, second once and fourth once during the six years. The other trees have been more variable, but trees Nos. 2 and 8 have shown a tendency toward elongation. As with size the differences in form are more constant in the different parts of the trees than with the different trees. The upper south apples have been the most flattened every year, but those of trees Nos. 1 and 3 from the lower north portions have been the most elongated four years out of six. The other two portions of the trees have been more variable, but the lower souths have been slightly the more flattened. As regards the standard deviation and the coefficient of variability, they do not seem to have any significance whatever; such small differences as occur are probably wholly chance fluctuations.

Turning now to the discussion of the difference in form from year to year and its relation to air temperature, which has been the main object of inquiry, we find that the paralellism between the variation and the temperature for a period following blossoming previously observed has been maintained in succeeding years. This relationship is shown in Fig. 1, which shows the fluctuations in mean daily temperature for twenty-five days following full bloom. This shows that a low temperature following blossoming is always followed by a low coefficient of form, *i.e.*, relatively elongated apple. The past season of 1913 has been the coolest of any for nearly the whole period of twenty-five days, and the apples have been the most elongated, while in 1908, 1911 and 1912, in which this period was relatively warm, the coefficient of form is much larger, *i.e.*, the apples are more flattened. In the other years both the temperatures and coefficients of form have been intermediate.

The curves of temperature, not only for the period shown in the diagram but for the entire growing season as well, have been carefully scrutinized to ascertain the critical period which determines the form of the apple. Consideration has also been given to other factors of climate, such as rainfall, humidity and sunshine, — whether they may have an effect. As a result of this inquiry there appears no evidence that factors other than that of temperature for a part or all of the twenty-five-day period have any influence. Within this period the temperature from the sixth to

[1] Mass. Expt. Station Rept.: 23, Pt. I. (1911), p. 199.

Figure 1. Fluctuations of daily mean temperatures for periods of 25 days following full bloom of the Ben Davis also indexes of form for the corresponding years.



Days Following Full Bloom.

Vertical Scale 1" = 10°

Index of Form.

1908=1.1515. 1910=1.1238 1912=1.1536.

1909=1.1338 1911=1.1579 1913=1.1192.

sixteenth day seems to fit the observed fluctuations in form better than that for any other period. The relationship of the temperature for this period and the coefficient of form are as follows, the arrangement being in the order of the increase of temperature: —

Year.	Date of Full Bloom.	Temperature, Sixth to Sixteenth Day.	Coefficient of Form.
1913,	May 7,	51.24	1.1192
1910,	May 7,	54.44	1.1238
1909,	May 19,	58.19	1.1338
1912,	May 11,	62.10	1 1536
1908,	May 19,	67.63	1.1515
1911,	May 15,	67.76	1.1579

An inspection of these figures shows the general relationship, but there are some irregularities, especially in 1912 and 1908. In the latter year this period was slightly over 5° warmer than in 1912, yet the apples were more elongated. Tree No. 8 was not measured in 1908, but its apples have only once been more flattened than the average and then only slightly so. The difference between extremes of temperature for this period is 16.52° (67.76°–51.24°), and in the coefficient of form, .0387 (1.1579–1.1192). This gives an average difference of .0022 for each degree of temperature. If we calculate the relationship of the increase of the coefficient of form with that of temperature from year to year we get the following: —

Year.	Increase of Temperature.	Increase of Coefficient of Form.	
		Theoretical.	Actual.
1913,	0	0	0
1910,	3.20	.0070	.0046
1909,	6.95	.0151	.0146
1912,	10.86	.0238	.0344
1908,	15.39	.0339	.0328
1911,	16.52	.0363	.0387

Looked at from this viewpoint the only very serious difference between the actual and theoretical increases of the coefficient of form with the rise of temperature is in 1912, when it is 1.1536, whereas it should be, in order to be in harmony with other years, 1.1430. We have endeavored to account for this irregularity, but without success. Presumably some unknown factor operated to disturb the fairly close relationship observed in other years. Probably it will be necessary to attack the problem from another angle in order to understand what this may be.

TABLE 2.—*Form of Apples.*

Ben Davis.

INDIVIDUAL TREES.

Tree No. 2.

[Millimeters.]

YEAR.	Mean.	Standard Deviation.	Coefficient of Variability.
1908,	1.1422±.0014	.0576±.0009	3.04±.08
1909,	1.1248±.0024	.0553±.0017	4.91±.15
1910,	1.1159±.0016	.0516±.0012	4.62±.12
1911,	1.1526±.0006	.0458±.0004	3.97±.04
1912,	1.1510±.0016	.0510±.0009	4.43±.09
1913,	1.1282±.0014	.0584±.0010	5.18±.09
Average,	1.1358	.0533	

Tree No. 3.

YEAR.	Mean.	Standard Deviation.	Coefficient of Variability.
1908,	1.1399±.0016	.0543±.0011	4.73±.09
1909,	1.1297±.0020	.0553±.0014	4.89±.19
1910,	1.1322±.0015	.0488±.0011	4.31±.11
1911,	1.1662±.0008	.0456±.0005	3.91±.05
1912,	1.1508±.0016	.0586±.0011	5.09±.09
1913,	1.1282±.0012	.0547±.0008	4.85±.07
Average,	1.1412	.0529	

Tree No. 5.

YEAR.	Mean.	Standard Deviation.	Coefficient of Variability.
1908,	1.1666±.0019	.0626±.0013	3.76±.08
1909,	1.1295±.0028	.0519±.0019	4.59±.19
1910,	1.1151±.0018	.0512±.0013	4.59±.12
1911,	1.1559±.0008	.0453±.0006	3.92±.05
1912,	1.1571±.0018	.0549±.0014	4.75±.12
1913,	1.1201±.0009	.0492±.0007	4.39±.07
Average,	1.1418	.0526	

Tree No. 7.

YEAR.	Mean.	Standard Deviation.	Coefficient of Variability.
1908,	1.1716±.0019	.0578±.0013	3.37±.07
1909,	1.1486±.0017	.0511±.0012	4.45±.11
1910,	1.1333±.0014	.0516±.0010	4.55±.09
1911,	1.1716±.0010	.0528±.0007	4.51±.06
1912,	1.1563±.0012	.0483±.0008	4.17±.07
1913,	1.1170±.0012	.0549±.0008	4.91±.07
Average,	1.1497	.0527	

TABLE 2.—*Form of Apples*—Continued.

Tree No. 8.

[Millimeters.]

Year.	Mean.	Standard Deviation.	Coefficient of Variability.
1909,	1.1310±.0013	.0494±.0010	4.37±.09
1910,	1.1211±.0007	.0481±.0005	4.29±.05
1911,	1.1558±.0006	.0455±.0005	3.93±.04
1912,	1.1540±.0013	.0491±.0009	4.14±.08
1913,	1.1099±.0006	.0473±.0008	3.94±.07
Average,	1.1342		

PARTS OF TREES.

Upper South.

1908,	1.1643±.0017	.0593±.0012	3.61±.07
1909,	1.1390±.0015	.0520±.0011	4.57±.10
1910,	1.1299±.0013	.0500±.0009	4.43±.09
1911,	1.1610±.0004	.0486±.0005	4.19±.04
1912,	1.1557±.0012	.0505±.0009	4.37±.07
1913,	1.1283±.0009	.0513±.0006	4.55±.06
Average,	1.1464	.0523	

Lower South.

1908,	1.1512±.0015	.0619±.0011	4.19±.07
1909,	1.1302±.0018	.0516±.0012	4.57±.12
1910,	1.1249±.0011	.0489±.0009	4.35±.08
1911,	1.1614±.0009	.0468±.0005	4.03±.04
1912,	1.1609±.0014	.0461±.0010	3.97±.08
1913,	1.1156±.0007	.0416±.0005	3.73±.05
Average,	1.1407	.0496	

Upper North.

1908,	1.1553±.0020	.0607±.0014	3.91±.08
1909,	1.1333±.0020	.0509±.0014	4.40±.14
1910,	1.1216±.0016	.0544±.0010	4.85±.10
1911,	1.1598±.0004	.0470±.0005	4.05±.04
1912,	1.1430±.0013	.0487±.0009	4.26±.08
1913,	1.1241±.0010	.0527±.0007	4.34±.06
Average,	1.1395	.0527	

TABLE 2.—*Form of Apples*—Continued.

Lower North.

[Millimeters.]

Year.	Mean.	Standard Deviation.	Coefficient of Variability.
1908,	1.1406±.0016	.0644±.0011	4.58±.07
1909,	1.1338±.0021	.0529±.0015	4.67±.14
1910,	1.1171±.0012	.0505±.0008	4.52±.08
1911,	1.1511±.0006	.0454±.0004	3.95±.04
1912,	1.1537±.0018	.0505±.0012	4.37±.11
1913,	1.1065±.0009	.0529±.0007	4.78±.06
Average,	1.1338	.0528	

TOTAL APPLES.

Year.	Mean.	Standard Deviation.	Coefficient of Variability.
1907,	1.1656±.0023	.0581±.0017	4.98±.14
1908,	1.1515±.0008	.0589±.0006	5.29±.05
1909,	1.1338±.0009	.0527±.0006	4.65±.06
1910,	1.1238±.0007	.0504±.0004	4.48±.04
1911,	1.1579±.0003	.0472±.0002	4.07±.02
1912,	1.1536±.0006	.0499±.0004	4.33±.04
1913,	1.1192±.0005	.0518±.0003	4.63±.08

Baldwins.

INDIVIDUAL TREES.

Tree No. 2.

Year.	Mean.	Standard Deviation.	Coefficient of Variability.
1909,	1.1615±.0022	.0579±.0015	4.98±.13
1910,	1.1745±.0021	.0536±.0015	4.56±.15
1912,	1.2006±.0023	.0605±.0016	5.04±.14

Tree No. 4.

Year.	Mean.	Standard Deviation.	Coefficient of Variability.
1909,	1.1848±.0014	.0523±.0010	5.41±.10
1910,	1.1834±.0027	.0553±.0019	4.67±.17
1911,	1.2342±.0008	.0469±.0006	3.80±.05
1913,	1.1962±.0024	.0774±.0017	6.47±.15

TABLE 2. — *Form of Apples* — Concluded.

Tree No. 5.

[Millimeters.[

Year.	Mean.	Standard Deviation.	Coefficient of Variability.
1909,	1.1790±.0024	.0644±.0017	5.46±.16
1910,	1.1878±.0018	.0622±.0013	5.23±.12
1911,	1.2307±.0027	.0637±.0019	5.18±.16
1912,	1.2248±.0011	.0485±.0008	3.96±.07

TOTAL APPLES.

Year.	Mean.	Standard Deviation.	Coefficient of Variability.
1909,	1.1774±.11	.0583±.08	4.96±.07
1910,	1.1844±.12	.0567±.08	4.79±.07
1912,	1.2180±.10	.0502±.07	4.27±.06

SUMMARY.

1. These Ben Davis trees have borne much more heavily than the Baldwins and have shown hardly any tendency to biennial bearing.

2. Among five Ben Davis trees the most prolific tree has exceeded the least prolific by more than 60 per cent. in number of apples in the total for six crops. The Baldwins have shown even greater differences.

3. The upper south quarters of the Ben Davis trees have borne a few more apples than any of the other three quarters. This may be significant or only a chance difference.

4. Some Ben Davis trees showed a fairly constant tendency to produce apples larger or smaller than the average; others fluctuated from season to season.

5. Ben Davis apples from the upper south quarters of the trees run constantly larger than those from the other parts; those from the opposite quarters were generally smallest.

6. Only once in the case of a very heavy crop has the number of apples been large enough to affect the size.

7. There are some slight indications of a relationship between size and the average summer temperature, but the fluctuations in temperature have probably not been large enough to overcome other influences affecting size.

8. Some trees showed slight individuality in the amount of variability, and this may be correlated with size, — the larger the apples the more variable. This is not true as between the different parts of the trees.

9. As with size, some trees showed quite constant individuality in form of fruit, while others were variable. There seems to be no strong evidence that individuality in size and form are to be found in the same tree.

10. The apples from the upper south parts of the trees, which were largest, were also constantly the most flattened.

11. There is a pretty constant relationship between the form of the apple and the temperature for a period following bloom; the cooler this period the more elongated the apple.

12. An effort to delimit this period more closely indicates that the period from the sixth to the sixteenth days following full bloom fits the observed fluctuation in form more closely than any other.

REPORTS ON EXPERIMENTAL WORK IN CONNECTION WITH CRANBERRIES.

H. J. FRANKLIN AND F. W. MORSE.

REPORT OF CRANBERRY SUBSTATION FOR 1913.[1]

The year's experiments and observations may be discussed under the ten following heads: weather observations, frost protection, fungous diseases, varieties, blossom pollination, fertilizers, insects, weeds, resanding and miscellaneous.

1. WEATHER OBSERVATIONS.

Blanks have been prepared for recording on a single sheet all the more important phenomena observed in connection with every frosty night during the cranberry growing season. On these blanks space has been left for recording the minimum temperatures at 15 stations (bogs) besides that at the station bog. It is also planned to note in this record the amount of injury (estimated) on the Cape and in New Jersey caused by each severe frost. It is hoped that the mass of data condensed in such records will make it possible to better understand the Cape frost weather conditions and to make more satisfactory frost predictions as a result. Only a few of the temperature observing stations planned for have, as yet, been established, but it is hoped that another season will see all the thermometers properly placed for taking a fairly representative lot of minimum temperature observations for the entire Cape. The barometric changes and their influence on frost conditions, both as indicated by the weather map and as shown by the action of the barometer itself, have been carefully studied, with some interesting results. The high barometric waves appear, as a rule, to be most dangerous when they extend both far to the North and far to the South, without any low wave on the Atlantic seaboard to the south of us. One of the great uncertainties about the barometric action, as far as the weather map is concerned, seems to be caused by the occasional more rapid deepening of a low wave in or around the lower St. Lawrence valley, than is offset by the advance of the high wave, the general result being a fall of the barometer in an important

[1] By H. J. Franklin.

section where a rise would, as a rule, be expected. This fall of the barometer in the northeast often causes the wind to keep up all night when other conditions would lead a forecaster to expect almost a dead calm. There seems to be no way of figuring on this action of the barometric waves, except by more extensive observations of conditions in the eastern Provinces of Canada than are at present carried out by the Weather Bureau. The officials of the Weather Bureau are planning to take special afternoon barometric observations in that section, in order to forecast our frost conditions more accurately.

Another puzzling factor is the occasional occurrence of cloudiness on mornings when, from the general weather conditions, no cloudiness would naturally be expected. It seems quite possible that we may not be able to fully understand the causes of such cloudiness without a study of the conditions of the upper atmosphere. This is of course a very important matter, for the presence of clouds always makes a difference of several degrees in the temperature of a cold night.

The readings of the maximum and minimum shelter and bog thermometers, and the amounts of precipitation, were telegraphed to the office of the United States Weather Bureau at Boston, every morning after May 4, during the spring and fall periods of frost danger. Triple register (for sunshine, wind direction and wind velocity), thermograph, and barograph records were taken in the usual way throughout the season, from early May until the last of October. As the hydrograph did not work satisfactorily no records were made with that instrument.

There seems to have been this year a general increase in confidence, on the part of the growers, in the forecasts sent out from the Boston office of the Weather Bureau. This increased confidence is probably fully justified, for the forecasts seem to have been much more accurate during the past season than formerly.

2. FROST PROTECTION.

Careful consideration has been given to the different possible methods of frost protection where water is not available for use in the usual way.

It was suggested in last year's report that it might be possible to use the Skinner system, or some other sprinkling arrangement, with an engine and pump only large enough to pump water for one section at a time, the idea being to draw the frost out of the vines by one or two applications of cold water in the morning, before they were thawed out by the heat of the sun. The practicability of this method was tried out on a small scale last May with a spraying outfit, and the results seemed to be far from satisfactory, for the sprayed areas afterward appeared to show distinctly more injury than did the surrounding unsprayed portions of the bog. As the whole matter now stands, therefore, it does not seem at all probable that the Skinner system can very well ever be made practical use of for frost protection. Its undesirability from the standpoints of expense and nozzle clogging were discussed in last year's report. All other

sprinkling systems at present on the market are even more expensive, and will probably, on this account, never be practically available for this purpose.

As indicated in last year's report, the expense connected with the use of orchard heaters is prohibitive, to say nothing of the danger from fire, and of the injury to the vines which would unavoidably be done by the spilling of oil.

There are many other possible methods of frost protection for cranberry bogs which have not yet been tried. It may be possible to cause the frost to be drawn out slowly from the vines after a frost by screening the bog from the sun during the first two or three hours of the morning, perhaps by a curtain of smoke. This method is suggested by the well-known fact that the greater part of the injury, caused by freezing in both plant and animal tissues, is usually due more to the sudden withdrawal of the frost in the process of thawing than to the formation of the frost in them.

The possibility of protecting a bog from frost by covering it over with cloth is of course generally recognized. Though this would be an expensive protection, it has the probable advantage of being entirely effective. It is, however, probably unwise to attempt any special frost protection on dry bogs because of the peculiar conditions and difficulties otherwise associated with such bogs. The only kind of bogs, the general conditions of which probably warrant special protection, are those which are winter-flowed but cannot be reflowed to any extent.

As a rule, the managers and owners of most of the Cape bogs, which have poor frost protection, seem to have overlooked the method of protection, which, though not perfect, is, nevertheless, many times very effective, and which can be applied with a relatively small cost, namely, that of keeping the bog well sanded. It has been shown by the experiments carried out by Prof. H. J. Cox for the United States Weather Bureau and by the Wisconsin Station that there is a protection against several degrees of frost to be had by this use of sand. Many of the Cape growers have come to realize this from general experience, and striking examples of the efficiency of this protection are not infrequently seen. It seems certain that a very considerable percentage of the Cape cranberry losses from frost, incurred where water protection is not available, could be saved by a more general understanding and application of this principle of re-sanding for protection.

3. FUNGOUS DISEASES.

The arrangement by which this work has heretofore been carried on in co-operation with the Bureau of Plant Industry of the United States Department of Agriculture has been continued this year. Dr. Shear has had general supervision of the spraying experiments as heretofore and has conducted the laboratory investigations. A considerable number of spraying tests were carried on by the growers, especially in Wareham and in and about Harwich, the results of some of which have not as yet

been received. The five plots, each four rods square, which were sprayed in 1911 and 1912 as indicated in previous reports, were all sprayed again this season with Bordeaux mixture used in the same way as last year (3 pounds of lime, 4 pounds of copper sulphate and 2 pounds of resin fish oil soap to 50 gallons of water), but a greater number of times, plots A and C (Lake Howe plots) being sprayed with the Bordeaux on June 5, June 17, June 28 and July 19, and with neutral copper acetate (1 pound to 50 gallons of water) on August 7. Plot B (the McFarlin plot) was sprayed with Bordeaux mixture on June 6, June 18 and July 21. Plots D and E (the Early Black plots) were sprayed with Bordeaux mixture on June 6, June 18, July 11 and July 22. The crop was gathered from these plots and their checks on dates and in amounts as follows, the quantities being given in bushels: —

TABLE 1.

PLOT.	Area (Square Rods).	Date when picked.	Variety.	Quantity of Fruit (Bushels).	Quantity per Square Rod (Bushels).	Average of Double Checks per Square Rod.	Per Cent. of Decrease on Sprayed Plots.
A, ...	16	Sept. 24	Howe.	8⅙	.5100	-	74
A (check 1), .	4	Sept. 25	Howe.	4 1/15	1.0170	1.942	-
A (check 2), .	9	Sept. 25	Howe.	25⅘	2.8660		
B, ...	14⅛	Sept. 25	McFarlin.	13¼	.9380	-	49
B (check), . .	13⅔	Sept. 25	McFarlin.	25	1.8300	-	-
C, ...	16	Sept. 24	Howe.	9	.5625	-	53
C (check 1), .	4	Sept. 24	Howe.	5	1.2500	1.198	-
C (check 2), .	8	Sept. 24	Howe.	9⅙	1.1460		
D, ...	16	Sept. 17	Early Black.	19⅔	1.2300	-	45
D (check 1), .	3	Sept. 17	Early Black.	6⅖	2.1330	2.240	-
D (check 2), .	9	Sept. 24	Early Black.	21⅑	2.3460		
E, ...	16	Sept. 3	Early Black.	21½	1.3440	-	26+
E (check 1), .	8	Sept. 3	Early Black.	15	1.8750	1.830	-
E (check 2), .	4	Sept. 3	Early Black.	6½	1.6250		
E (check 3), .	4	Sept. 3	Early Black.	8	2.0000		

It will be seen from this table that there was a general very marked falling off in the fruit produced by these sprayed plots as compared with the surrounding untreated portions of the bog. Where two checks were laid out for the same plot (as noted in the table), they were in every case located on different sides of the sprayed area. The berries were all picked with scoops. The spraying was done with a 30-gallon wheeled-barrel outfit, as heretofore, but the mechanical injury done in the process of spraying was not very great, as a long hose was used, and the outfit was in

no case taken onto either the sprayed areas or their checks. The general result of this spraying is interesting in the light of the observations made in connection with the Early Black and McFarlin plots in the late fall of 1912. At that time it was noticed that these plots seemed to have foliage of a much lighter and more sickly appearance than was shown by the vines of their checks. As noted in last year's report, this contrast was very marked and led to the suspicion that, on account of the evidently unthrifty condition of the sprayed areas, they would not, in the season of 1913, produce as good a crop as their checks. The situation suggests that there was not sufficient available plant food present for the sprayed vines, while they were producing the 1912 crop, to maintain a strong vine condition and at the same time develop the extra amount of fruit which the reduction of fungous diseases, caused by the spraying, had made possible. Whether this was the real cause for the decreased fruiting of these plots, or whether the spraying had done the bog injury in some unknown way, it is, as yet, impossible to state with certainty. It should be noted in this connection that in the fall of 1913 the vines of all these plots showed an even more marked unthrifty and sickly appearance in comparison with their checks than they did in the fall of 1912, though they had not, as shown in the table, produced nearly as large crops as the checks. The Howe plots (A and C), which did not show in 1912 any marked effect on the vines, in the fall of 1913 were so red all over (except the fertilized middle portion of plot A) as to give the impression, to one viewing the bog from a distance, that the fireworm had been working severely on them. This would seem to indicate that the spraying had in some way caused a cumulative injury.

On June 28, the middle half of plot A (one of the Howe plots) was fertilized, a quarter of the plot on each side being left without fertilizer, the fertilizer being used on the middle portion at the following rate: nitrate of soda, 200 pounds per acre; acid phosphate, 400 pounds per acre; high-grade sulphate of potash, 200 pounds per acre. This fertilized middle half (8 square rods) of the plot produced 5 1/12 bushels of berries, while the unfertilized side strips (the area of each being 4 square rods) produced, respectively, 1 1/12 bushels and 2 bushels. It will be seen from these figures that there was a very marked increase of fruit on the middle portion, due to the application of the fertilizer. This is particularly interesting because, at the time when the fertilizer was applied, the vines were going out of bloom, and there was no rain to speak of, to dissolve the fertilizer and wash it into the soil, for several days after the application. It is the first time in our experience that fertilizers have been known to cause a marked increase in the amount of fruit on a cranberry bog in the first season applied. This is suggestive in several ways. It looks as though vines which have borne a larger crop, due to freedom from fungous disease brought about by spraying, need an extra supply of plant food the following year in order to maintain their vigor and hold their own in fruiting with unsprayed vines. The results of this fertilizing

and spraying may perhaps also be taken to indicate that fertilizers will do their best work in driving fruit production only when the vines are comparatively free from fungous disease. They also suggest the possibility that there is a best time for applying fertilizers, in order to get the best fruiting, perhaps at about the blossoming period. A rather marked increase in fruit production, following a first application of fertilizers rich in nitrates, during the blossoming period, on Howe vines, was noted on some other bogs toward the close of the season. There seems to be much yet to be learned along these lines by further experimenting.

An unexpected result of the spraying, noticed on all five of our old fungous plots during the season, was the killing of the wood moss. This moss appears to have been completely killed out on every one of these plots, while, on the general bog surrounding some of them, it is present in considerable abundance and very much alive up to the very edge of the plot.

When the fruit was gathered from these five plots, no marked difference in color between the berries from the sprayed plots and their checks was observed. The size of the berries from the Early Black and McFarlin plots was practically the same as that of the berries from the checks, but the berries from plots A and C (Howe plots) were distinctly smaller than those from their checks, as shown by the following averages of counts of berries in cupful samples (New England Cranberry Sales Company's inspector's cup) from the different plots and their checks, the samples being in each case taken as evenly as possible from the various boxes: —

Table 2.

Plot.	Number of Samples counted.	Average Number of Berries per Sample.	Variety.
A (fertilized middle portion),	8	96	Howe.
A (the unfertilized side portions),	4	97	Howe.
A (check),	8	90	Howe.
B,	8	60	McFarlin.
B (check),	8	61	McFarlin.
C,	8	102	Howe.
C (check),	8	96	Howe.
D,	6	113	Early Black.
D (check 1),	4	110	Early Black.
D (check 2),	6	108	Early Black.
E,	6	109	Early Black.
E (check),	6	109	Early Black.

The keeping qualities of the berries from these five old fungous plots and their checks were tested, with the results shown in the following table: —

TABLE 3.

PLOT.	Date picked.	Test begun.	Test ended.	Quantity tested (Boxes).	Quantity of Sound Fruit after screening (Boxes).	Percentage of Loss.	Variety.
A (fertilized middle portion).	Sept. 24	Oct. 28	Dec. 19	4	3 3/8	15 2/5	Howe.
A (unfertilized side portions).	Sept. 24	Oct. 28	Dec. 19	2	1 2/3	17 2/3	Howe.
A (check), . .	Sept. 24	Oct. 28	Dec. 20	4	3 1/14	23 1/6	Howe.
B, ...	Sept. 25	Oct. 28	Dec. 23	4	3 1/13	23	McFarlin.
B (check), . .	Sept. 25	Oct. 28	Dec. 23	4	3	23	McFarlin.
C, ...	Sept. 24	Oct. 28	Dec. 19	4	3 5/8	10 3/10	Howe.
C (check), . .	Sept. 24	Oct. 28	Dec. 19	4	3 1/7	21 1/3	Howe.
D, ...	Sept. 17	Oct. 28	Dec. 22	3	2 1/11	30 2/5	Early Black.
D (check 1), . .	Sept. 17	Oct. 28	Dec. 20	2	1 1/4	38 1/4	Early Black.
D (check 2), . .	Sept. 24	Oct. 28	Dec. 23	3	1 2/3	44 1/8	Early Black.
E, ...	Sept. 3	Oct. 28	Dec. 17	3	2 1/2	17 2/3	Early Black.
E (check), . .	Sept. 3	Oct. 28	Dec. 17	3	2 1/8	29 2/5	Early Black.

The boxes used in measuring for these tests, as well as for all other keeping tests conducted during the season, measured 19 1/4 inches by 14 1/2 inches by 8 1/2 inches, and no considerable error was allowed to creep into the measurement of the fruit on account of variation in the dimensions of the boxes. The fractions given in the above table are only approximate, it being considered that absolute accuracy is not of sufficient importance to call for the including of large numbered fractions. In all the season's storage tests the berries were stored without screening or hoppering. When they were picked, the vines were cleaned out from the boxes by hand as carefully as possible, so that there might be uniformity among the boxes in the quantity of vines they contained. When measured for storage (on October 28 and 29), the boxes were carefully shaken and filled level full, and after screening the berries were again thoroughly shaken before they were measured.

Judging from the figures, concerning the berries from plots D and E given in Table 3, it might be thought that these tests showed a superior keeping quality for early picked berries. While it is not, of course, impossible that this factor may have entered into the results of the tests, it should be borne in mind that the two plots in question are located on the bog at a considerable distance from each other, and there is always more or less variation in the berries of the same variety harvested from the different portions of the bog. Supporting this fact is the fact that last year the berries from plot D kept better than did those from plot E, the reverse of the results obtained by our keeping tests this year.

The results of the tests of the keeping qualities of the berries of the McFarlin plot and its check are remarkable in that they appear to indicate absolutely no effect resulting from the spraying, a result never before even nearly approximated in any test of berries, which had been sprayed with Bordeaux mixture, carried out at the station bog. It should be noted in this connection that the McFarlin berries, both sprayed and unsprayed, on the station bog, and apparently also on other bogs in its vicinity, kept unusually well this year, apparently as a natural result of the peculiar weather conditions.

Three new fungous plots were this season started on the station bog. One of these (on Howe vines) was sprayed with lime-sulphur solution, made from Frost's Powdered Lime-Sulphur, on June 7, June 18, June 28, July 21 and August 7. This plot was picked on September 28. Its area is 9 square rods, and it yielded 5⅓ bushels, while a check of 6 rods immediately adjacent yielded 12⅔ bushels. The marked decrease on the sprayed area was probably due to some injury caused by the spray. The berries from this plot and its check were tested for keeping quality, the results being in favor of the check, the percentage of loss among the berries of the plot being 34½, while amongst those of the check it was only 25½. As far as the results obtained from this plot are concerned, therefore, there seems to be nothing to be said in favor of this preparation for use as a cranberry fungicide. It is planned to continue this test another season.

Another of the new plots was sprayed with Bordeaux mixture, prepared in the usual way, on June 7, June 17, June 28 and July 21, and with neutral copper acetate on August 7. The area of this plot is 9 square rods and it yielded 7⅓ bushels, while its check of equal area yielded 12 bushels. In the storage tests the loss among the berries from this plot was approximately 17 per cent., while its check showed a loss of 27⅕ per cent.

One-half of the fertilizer plot which had, previous to 1913, been treated the most heavily with nitrate of soda, was also sprayed during the season, for the first time, for the purpose of learning about the combined results of fertilizing and fungous spraying. The spraying with Bordeaux mixture was done on June 6, June 17, July 11 and July 21, and neutral copper acetate was used on August 7. The whole fertilizer plot (plot 15) was picked on September 16, and the sprayed portion yielded only 3½ bushels, while the unsprayed portion gave approximately 6⅓ bushels. In the keeping tests, begun with these berries on October 28 and ended on December 22, the sprayed berries showed a loss of only 31⅖ per cent., while the unsprayed lost 44⅗ per cent.

It will be seen from the figures here given that there was a marked decrease in the fruit production on both of the two new plots treated with Bordeaux mixture and neutral copper acetate. This is in accord with the results generally obtained in the co-operative spraying tests carried on on other bogs by the growers during the season, at least in those tests in which spraying was done during the blooming period. While it is impos-

sible to say definitely what caused the falling off in the fruiting on the sprayed areas, it seems highly probable that the Bordeaux mixture was in some way injurious when used during the blooming period. This can be determined only by further tests.

The new disease, spoken of as the "blossom end rot" in last year's report, was much in evidence, after picking, among the Howe berries of the station bog again this year, most of the rot among those berries being evidently due to it. During the month of October, samples of Howe berries were collected from 54 different bogs, for the purpose of gaining some knowledge concerning the distribution and severity of this disease on different parts of the Cape, as such knowledge seemed not only desirable from the scientific standpoint but also more or less essential for practical purposes. The bogs from which these samples came were distributed as follows: Chatham, 2; Harwich, 4; Mashpee, 1; Falmouth, 1; Nantucket, 1; Wareham, 16; Carver, 7; Marion, 2; Rochester, 2; Plymouth, 3; Middleborough, 2; Pembroke, 2; Hanson (including Bryantville and South Hanson), 11.

The "blossom end rot" was found to be present in varying amount in all the samples collected, and the examinations (made from December 11 to December 15, inclusive) appeared to produce no certain evidence that there is any very distinct sectional variation in the degree of its prevalence among the different portions of the Cape. The largest percentage of loss found to have been certainly caused by this disease, at the time of examination, in any of these collected samples, was roughly 8½ per cent., and the smallest loss found in any sample was roughly 1⅓ per cent. Much of the rot present, however, which did not show the characteristics of this disease definitely was probably, nevertheless, caused by it.

Experiments with Copper Sulphate in the Flowage.

In June, tests were begun looking for the control of fungous diseases on cranberry bogs by the application of copper sulphate in the flowage. These tests were carried out on the flooding sections of the station bog. The strengths of the copper sulphate tried were 1 part to 50,000 parts of water (1 pound in 6,250 gallons) on sections 23 and 25 and 1 part to 100,000 parts of water (about 1 pound in 12,500 gallons) on section 27. The copper sulphate was first dissolved in pails of water, and the solutions were distributed as evenly as possible in the flowage of these sections by throwing them into the flowage by the cupful. This treatment was applied to these sections on June 3 and again on June 16.

On section 23, each treatment was continued about twenty-three hours, the chemical being applied to the flowage within an hour or two after the section was completely flooded. As the whole bog was flooded at the same time that the flooding sections were flowed for this treatment, the vines were more or less wet for several hours before the copper sulphate was put in the water.

On section 25 the treatment was continued for eleven hours and was applied after twelve and one-half hours of complete flooding without treatment.

On section 27 the duration of the treatment was about eleven hours and as with section 25 followed twelve and one-half hours of complete flooding without treatment.

When the first treatment was applied to these sections the blossom buds were well developed and prominent, and when the second treatment was applied they were approaching near to blooming, there being here and there a blossom already opened. The treatment did not appear to affect the buds on sections 25 and 27 injuriously in any way. Some of those on section 23, however, were spotted slightly, showing that the solution used had probably been fully as strong as was desirable.

The strength of the solution used on section 23 was recommended to me by Dr. Shear, as the result of laboratory experiments which he had conducted. Unfortunately, spanworms worked seriously on section 23 and reduced the crop to such an extent as to destroy the results of the experiment so far as the amount of the fruit might give any evidence concerning the effect of the treatment.

At picking time sections 25 and 27 yielded fruit at approximately the same rate as the untreated flooding sections immediately adjacent, while section 23 showed a marked falling off. These sections were picked on September 2.

The berries from all the flooding sections were tested for keeping quality, the period of storage extending from October 29 to December 17. The treated sections 25 and 27 showed little if any improvement over the untreated sections. The berries from section 23 seemed to keep better than those from the other flooding sections, but the difference was not sufficiently marked to justify the conclusion that the copper sulphate treatment had been decidedly beneficial.

4. VARIETIES.

Investigations looking toward the possible development of more desirable and more prolific varieties were continued, especially prolific vines of the late Howe and Vose's Bell varieties being marked for observation next season. Some interesting and apparently valuable sports of the Late Howe variety were also found and were marked. Unfortunately, the majority of the uprights, marked in previous years on account of their prolificness, did not bear well in 1913, though there were a few exceptions.

Samples of the berries of most of the different varieties grown on the Cape were collected in October. Samples of vines were also collected where it was possible to get them without too much trouble. Later these samples were studied more or less carefully, and the varieties which appeared to be mixtures of two or more distinct varieties were separated in a general way into their component parts. From these collected samples smaller samples, numbering in all 180, were taken and bottled in alcohol

and formalin for future study and reference. The following are the varieties which were thus sampled, together with the number and general location of the bogs from which samples of each were taken: —

TABLE 4.

Variety.	Number of Bogs from which Samples were taken.	General Location of these Bogs.
Early Black,	1	East Wareham.
Late Howe,	1	East Wareham.
Early Red,	2	Wareham (East and West).
Early Red (?),	1	East Wareham.
Centerville,	2	South Carver and East Wareham.
Perry Red,	1	Marion.
Matthew,	8	East Wareham, Pleasant Lake, Bryantville and South Chatham.
Jersey Berry,	1	West Wareham.
Centennial,	3	Carver.
Champion,	1	Carver.
Mammoth,	2	Bryantville.
Bugle,	5	Santuit, Carver, Bryantville and East Wareham.
Horseneck,	1	Marion.
Berry Berry,	2	Wareham.
Samuel Small's Bugles,	1	Harwich.
McKinley (or Berlin),	1	Chatham.
Cherry Berry,	1	Plymouth.
McFarlin,	5	Carver and East Wareham.
"Howe,"	1	Wareham.
"Howe,"	1	East Wareham.
"Howe,"	1	East Wareham.
Carver Red,	1	Marion.
Unknown Variety,	1	Mashpee.
Vose's Bell (or Pride),	1	Marion.
Shaw's Success,	2	Carver.
Reds,	1	Bryantville.
Smalley's No. 1,	1	East Wareham.
Smalley Berries,	2	South Harwich and East Wareham.
Hocanun,	1	South Hanson.
Aviator,	1	Carver.
North Cape Howe,	1	Wareham.
Leonard Robbins' Berry,	1	Harwich.
Atkins' Seedling,	4	Brewster, Harwich and Plymouth.

Several of the less well known of these varieties, judging from the appearance and condition of the samples when they were examined in January and from the notes obtained when the collection was made, appear to have highly commendable qualities and would probably give a good account of themselves if they were more extensively planted.

5. BLOSSOM POLLINATION.

The plots, from which bees were screened out on the station bog during the blossoming periods of 1911 and 1912, yielded fruit in 1913 at approximately the same rate as the surrounding bog. A new plot was screened off during the 1913 blossoming period with wire netting through which no bee could work its way. There were a few blossoms present when the screen was put in place, but these were all carefully picked off. The crop on this plot was picked on October 8 and amounted to 2¾ quarts, the area of the plot being approximately half a square rod, while the crop produced on any equal area of the surrounding bog was not less than a bushel. It will be noted that this result was in accord with the general results obtained in all similar previous experiments, except that the results with last year's plot were not nearly so striking.

As it was evident at a glance that the margins of the 1913 plot were bearing more berries than its central portion, a margin 9 inches wide was marked off around the plot and picked separately. The total area of this margin was approximately 34 square feet, slightly more than one-fourth of the entire area in the plot, yet it yielded 664 berries, while the whole plot produced only 1,452. A further marked peculiarity noted was that the portion of this margin lying on the upland side of the plot bore much more heavily than did the remainder, the plot being located at the edge of the bog, just across the ditch from the upland.

While these observations seem suggestive, it does not seem that any definite conclusion can be drawn from them.

6. FERTILIZERS.

The station bog plots used in the 1911 and 1912 fertilizer tests were again treated in 1913 with the same kinds and quantities of fertilizer as before. Because of reflowing operations just before the bloom, the fertilizers were applied later than usual, — on July 15. At picking time it was found that the fertilized plots had not, as a rule, produced as many berries as the check plots, the reverse of the result obtained last year. The decrease on the fertilized plots was not very marked, however, except with plots 14 and 15, these being the two plots on which nitrate of soda had been used in the largest quantities. Plot 15 showed a much greater falling off than did 14, and it had received heavier applications of the nitrate than had 14. This result is somewhat surprising in view of the fact that these two plots had by far the heaviest blossom of any portion of the bog. For some reason, however, there was a marked drying up of the blossoms and small berries on these plots, especially on plot 15, not

observed to any such extent on other portions of the bog. The conditions were such that, all things considered, this drying up could not very well be laid to dry weather. The reduced fruiting seems to have been due to a detrimental effect of the nitrate, though it is perhaps impossible to say with certainty just what the effect was.

It must be remembered that half of plot 15 was this year sprayed for fungous diseases as well as fertilized, but the unsprayed portion showed a marked falling off in the quantity of fruit as well as the sprayed portion, though the reduction was not so great on the unsprayed part.

All the fertilizer plots were picked with scoops on September 15 and 16. The berries appeared so uniform in color and most other respects that no records were made except those concerning their quantity and size. The average counts of berries in several cup samples taken from each of the plots did not show any considerable differences in size that could apparently possibly be considered to have been caused by the fertilizer.

Storage tests were carried out with berries from all the plots, beginning on October 28 and 29 and ending December 17 to 23, the results of which did not appear to show any marked effect on the keeping quality, attributable to the use of the fertilizers, except with the berries from plot 15. The berries from this plot showed poor keeping quality, due apparently to the excessive use of nitrate of soda. It will be remembered, in this connection, that this plot has received heavier applications of the nitrate than have any of the others.

7. INSECTS.

This year saw a marked decrease in the prevalence of both the flowed-bog fireworm (black head cranberry worm) and the fruit worm. Last year the injury done by both of these insects was abnormally severe as compared with that of most of our recent seasons. This year, however, both insects caused comparatively little trouble, a surprising fact, considering the damage done by them last year. The causes of this year's reduction of these two pests are obscure, but it seems possible that some condition of the weather during some period of the year was responsible for it. If so, the most marked peculiarity noted in these conditions was the very open winter of 1912–13, especially during December and January. Probably the only way in which we can come to any definite conclusion concerning the bearing of weather conditions on the prevalence of these insects is to keep a careful record for a long period of years, and make comparisons of the experiences of one year with those of another.

The season of 1913 has had other peculiarities from the standpoint of cranberry insect troubles, especially in an unusual prevalence of cutworms and of spanworms of several different species. During the season numerous reports came in from cranberry growers, telling of threatening gypsy moth trouble, and the little cranberry snout beetle seemed to be more troublesome than usual.

On August 15, 1912, 42 pupæ of the spanworm, spoken of in last year's report as having done serious damage on the Old Colony bog at Yarmouth, were collected. They were kept on moist sand in cans through the fall, winter and spring. Between June 6 and 15, 33 moths emerged from these pupæ, but no parasites were obtained from them. Three of the pupæ which failed to produce moths appeared to be in good condition and were probably killed by overheating a few days before the moths would have emerged. Of the 33 which emerged, 17 were females and 16 were males. These moths were protandrous in emerging, for before June 11, 13 males and only 8 females emerged, while after June 10, 9 females and only 3 males emerged.

The Old Colony bog was visited on June 13, and the moths of this insect were found to be present in great numbers on an area of about 2 acres (estimated) which had not been treated in any way to get rid of the insect because that portion of the bog belonged to a separate and apparently careless owner. It was estimated that three-fourths of the moths present were males, though the proportions of the sexes were not carefully ascertained. Portions of the bog, which had been heavily infested in July and August, 1912, had been burned over in the latter half of August, and other infested portions had been resanded with seven-eighths to one and one-half inches of sand. Practically no moths of the spanworm were found on June 13 on any of these treated portions, except where the treated areas immediately adjoined untreated heavily infested areas. Evidently the burning had effectively destroyed the pupæ and the sanding had smothered them.

It should be noted that, though the bog had been completely under water for over four months, the winter flowage had not drowned any considerable percentage of the pupæ. This seems remarkable, for they were entirely naked (*i.e.*, were without any cocoon), and they lay fully exposed on the surface of the sand. Practically all of these pupæ found on the bog on June 13 showed distinct signs of life when they were picked up.

At the time of the visit to this bog (June 13) the millers on the infested portion were being caught and eaten (the males mostly, as this sex flew up into the air readily, sometimes as high as 25 or 30 feet, while the females, as a rule, being heavy with eggs and unable to fly well, stumbled and flopped along the ground when attempting to do so) by swallows (two barn swallows and a dozen or more tree swallows). These swallows were flying back and forth like bats, and the clicking of their bills was incessant as they captured the moths.

On June 15 the eggs were dissected out of several plump female moths and counted. These eggs were all bright green in color when fresh from the moth, but they afterward turned yellowish. They numbered 295 in the most productive moth and 187 in the least productive one. Eggs of this insect were found hatching in the laboratory on June 19 and 20.

On July 8 the Old Colony bog was visited again, and the following notes

concerning this insect were obtained from Mr. Ellis, the foreman of the bog, who seemed to be a very good observer: —

> The first worms of this insect were found on the bog on June 25. They were then very small. Unhatched eggs were also present in abundance on June 25. Small worms were seen in numbers spinning down the vines and hanging by small silken threads. Most of the moths had disappeared by June 18. The eggs on the vines were yellow and laid in scattering small batches (three to five together). The worms worked first on the backs of the leaves. On June 15 the female moths were more numerous and were scattered more widely over the bog than they were on the 13th, but the males were much less numerous on the 15th than they had been on the 13th. Females full of eggs were abundant on the 15th.

Mr. Ellis had been spraying a considerable part of the portion of the bog that was under his management, and his experience seemed to show that it is not very difficult to control this insect by thorough spraying with arsenate of lead.

On July 8 the worms (of many different sizes) were present on the badly infested portions of the bog in great numbers, the vines having been turned brown by their work and when opened appearing literally alive with them. So little foliage was left on the worst infested portions of the bog that death by starvation for a very large percentage of the worms seemed inevitable.

This insect was also found to be threatening a bog in Mattapoisett this year. Its scientific name is *Epelis truncataria* var. *faxonii* Minot. It has also been found feeding on the bearberry (*Arctostaphylos uva-ursi* L.).

A considerable number of parasites have been reared from the various cranberry pests, the names of which have not yet been determined. Some of these forms appear to represent species new to science. The species which have been named are listed in the following table: —

TABLE 5.

SCIENTIFIC NAME OF HOST.	Common Name of Host Insect.	Scientific Name of Parasite.	Order to which Parasite belongs.	Name of Expert who determined the Name of the Parasite.	Date of Emergence of the Parasite.	Number of Specimens obtained.	Stage of Host's Life-History from which reared.
1. *Peronea minuta* (Rob.),	Dry-bog fireworm,	*Exorista pyste* Walk.,	Diptera,	C. W. Johnson,	September 1 to 10.	10	Pupa.
		Phytodietus vulgaris Cress.,	Hymenoptera,	H. L. Viereck,	August 24, 1906.	1	-
		Pimpla conquisitor (Say.),	Hymenoptera,	H. L. Viereck,	- -	1	-
2. *Mineola vaccinii* (Riley),	Fruit worm,	*Phanerotoma tibialis* (Hald.),	Hymenoptera,	H. L. Viereck,	July 1 to 15.	Very many.	Larva.
		Microbracon dorsator (Say.),	Hymenoptera,	H. L. Viereck,	July 2, 1907.	1	-
3. *Cymatophora sulphurea* Packard,	Spanworm,	*Ichneumon extrematatis* Cress.,	Hymenoptera,	H. L. Viereck,	- -	1	-
		Euphorocera claripennis Macq.,	Diptera,	C. W. Johnson,	- -	1	-
4. *Calocampa nupera* Lintner,	False army worm,	*Winthemia quadripustulata* F.,	Diptera,	C. W. Johnson,	July 23, 1906.	1	Pupa.
5.	Bud worm,	*Tachina robusta* Town,	Diptera,	C. W. Johnson,	- -	3	-

The Diptera listed in this table are named according to Aldrich's catalogue. Prof. C. W. Johnson of the Boston Society of Natural History has adopted changes in their names as follows: *Carcelia pyste* instead of *Exorista pyste; Phorocera claripennis* instead of *Euphorocera claripennis;* and *Exorista robusta* instead of *Tachina robusta.*

A small Trypetid was reared from cranberries in small numbers last year. Mr. F. L. Thomas, a graduate student at the Massachusetts Agricultural College who is making an exhaustive study of the Trypetidæ of New England, has determined this insect to be a small variety of the apple maggot (*Rhagoletis pomonella* Walsh).

Experimental Insect Work.

The experimental work with insects has been confined mostly to the flowed-bog fireworm (black head cranberry worm) and the fruit worm. The work with these two insects is here discussed in order.

The Flowed-bog Fireworm (*Rhopobota vacciniana* (Pack.)).

In last year's report on this insect, the successful results obtained in the treatment of a certain large bog by holding the winter flowage late (until June 2) and then reflowing about three weeks later to destroy an infestation were fully discussed. A somewhat similar procedure was carried out on another but smaller bog this season with much less satisfactory results, due probably to the fact that the reflowing was done too soon. The results of this treatment, all things considered, seemed, however, to be sufficiently successful to support the belief that where this method of treatment can be applied it will be found at least a fairly satisfactory one. The reflowage should evidently be continued for about forty-eight hours in this treatment.

The ideas advanced in last year's report, as to the way in which the bunching up of the hatching of the eggs of this insect is brought about by the late holding of the winter flowage, were evidently erroneous, as shown by observations made this year. Tests with thermometers made during the June reflows of the station bog showed that there are greater differences of temperature among the vines of a cranberry bog when the bog is flowed than when it is open to the air, the conditions in this respect being exactly the reverse of what they were last year presumed to be. It now seems probable that the bunching of the hatching by the late holding of the water is brought about mostly by a retardation or prohibition of hatching for the first eggs that reach or approach the hatching stage. It seems evident that the worms from any eggs, which might become far enough advanced to hatch under water, would drown soon after hatching, and it is not impossible that this is what really happens to the eggs soonest developed while the eggs of slower development are catching up with them as the warming up of the water in the late spring allows them to develop. It is, of course, evident that the whole hatching process is naturally more rapid under the hot sun of June than it is when the development of the

eggs and their hatching takes place in the cooler weather of the first half of May, as usually occurs when the winter flowage is drawn off early.

The general position taken in last year's report in regard to the practice of spraying for this insect should probably be maintained. It seems possible, however, that instead of using Bordeaux mixture and Paris green for this spraying it will be found best to use arsenate of lead alone, for while some of the results with Bordeaux mixture have been satisfactory, there seem to be indications, as hinted in the discussion of the fungous work, that it may be, under some conditions at least, an injurious spray to use. Experiments are planned to find out more exactly about this. On some bogs where Bordeaux mixture and Paris green were used on one part and arsenate of lead on another, this year, the arsenate seemed to give rather distinctly better results.

We have not yet learned what is the best method of applying a spray to a cranberry bog. There is considerable diversity of opinion and experiments are planned along this line. It seems probable that in thick vines a spray driven with a good deal of force will place poison where it will have a more satisfactory effect in destroying this insect than will the poison of a spray lightly applied.

From observations made on a considerable number of bogs this year the fireworm seems to be distinctly more injurious on vines of the Late Howe variety than on those of the Early Black, and it seems probable that the late Howe is a favorite variety with the pest. If this is the case it is only an added indication that where bogs are being newly built it is the part of wisdom to plant only one variety on a bog. It is now becoming generally recognized that the planting of several varieties together on the same bog causes more or less serious inconvenience in many ways.

A detailed account was given in last year's report concerning the parasites and other natural enemies of this insect and concerning the bearing which bog flooding has upon their effective activity. In connection with this, attention should have been drawn to the fact that when a bog is reflowed after picking, the most conspicuous forms of animal life that are driven ashore by the water, from the standpoint of their numbers, are the spiders. The number of these forms seen by one looking for them on the occasion of such after-harvest reflowing is really surprising, and it is interesting to note that most of them, even on a bog of considerable size, succeed in reaching the upland alive, as they are fitted to float lightly upon the surface of the water for considerable distances if need be. In all his examinations of bogs made during the process of the after-harvest reflow the writer has as yet failed to see a sufficient number of parasitic insects driven up by the water to lead him to believe that they can have nearly as important a bearing on the prevalence of the fireworm as do the spiders. It is probable, however, that the presence of the parasites on a bog is, in a sense, more affected by the flowing than is that of the spiders, because they are probably far more liable to destruction by drowning

than are the spiders, and, moreover, the parasites affecting the fireworm are probably more or less peculiar to it, while its spider enemies are presumably not so to any considerable extent.

The Fruit Worm (*Mineola vaccinii* (*Riley*)).

The chief work of the year with this insect has been a study of its natural enemies. Nearly a dozen species of its parasites have now been reared, and the complete life-history of the most important one was worked out in a general way. The connection of this parasitic insect with the fruit worm has not been heretofore suspected. Mr. H. L. Viereck, an expert on the group of insects to which it belongs, has determined it to be a Braconid, to which has been given the name *Phanerotoma tibialis* (Haldeman). This insect is seen on the cranberry bogs in large numbers every summer during and after the blooming period, but its presence has not been accounted for until now. This year it was seen in greatest numbers during the first three weeks of July. The adults had almost entirely disappeared from the bogs by July 26, it being possible to find only now and then one on that date.

A large number of wormy berries were collected during August, 1912, and kept in cans until Aug. 1, 1913. A careful record was made both of the moths and of the parasites which emerged from them. The wormy berries used in this investigation came from three general locations, as follows: —

1. The center of a flowed bog (station bog).
2. The edge of a flowed bog (station bog).
3. A dry bog (that is, one not flowed at any time).

The record of moth and parasite emergence was kept with these locations in mind. The most interesting points brought out by the record thus obtained were: —

1. That *Phanerotoma tibialis* far outnumbered all the other parasites taken together. All the parasites obtained from the berries collected at the center of the station bog, and all but one of those from the berries from the edge of this bog, were of this species. About four-fifths of the parasites from the berries collected from the dry bog were also of this species, but the percentage of other species of parasites was much greater among the forms obtained from the dry-bog berries than among those from the berries of the flowed bog.

2. The berries from the dry bog produced nearly three times as many parasites in proportion to the fruit-worm moths which emerged, as did the berries from any portion of the flowed bog.

3. The time of the greatest emergence of the parasites, from the berries from all three locations mentioned, was from June 30 to July 9, inclusive.

4. As slightly more parasites than moths emerged from the worms of the berries from the dry bog, it seems highly probable that more than 50 per cent. of the fruit worms on that bog last year were killed by these parasites. This shows something of the importance of the natural enemies of this insect which we have been in the habit of considering as being comparatively free from parasites.

It will be observed that the relative number of parasites obtained from the flowed bog and from the dry one shows a similar condition, as regards the amount of parasitism present on dry and flowed bogs, as that which has already been found to prevail with the natural enemies of the fire-worm. From a study of the life-history of *Phanerotoma tibialis*, however, it is not easy to see just how the flowage can affect its prevalence to so marked an extent.

It was found that the adult *Phanerotoma* lays its egg in the egg of the fruit worm. It was not difficult to get one of these parasites to lay its egg under observation, by bringing near it a berry bearing, under one of the lobes of its blossom end, an unhatched fruit-worm egg. During their laying season these parasites are constantly running over the vines with actively vibrating antennæ, searching for the eggs of the fruit worm, and when a fruit-worm egg is presented to one of them, if the parasite's antennæ sense its location, it will give immediate attention to it, and the whole process of egg-laying may be observed. A peculiar fact discovered was that one of these parasites will never lay twice in the same fruit-worm egg. One of them can, however, be readily induced to lay an egg in a fruit-worm egg which already contains one or even several (twelve was the highest number reached in any test) eggs deposited by other individuals. It is not known whether the egg of the parasite hatches before the fruit-worm egg does or not, but at any rate the fruit worm when it emerges from the egg carries the small parasite with it, and as the fruit worm grows, the parasite within it also grows, feeding upon its juices and so depleting its vitality that when it becomes full grown and forms a cocoon around itself for the winter it is often but little more than half the size of a normal unparasitized worm. Some time during the winter or spring the parasite larva becomes full grown, and, emerging from the fruit worm, leaves it a mere dead shell, and forms its own tiny white cocoon about itself within the cocoon of the fruit worm. Within its cocoon it changes into the pupa stage, and it eventually emerges as an adult parasite nearly a year after it was deposited as an egg in the egg of the fruit worm.

The second most important parasite which was reared is a small Ichneumon, which lays its egg in the fruit worm after the worm has hatched and is already working in the berry. The name of this species has not yet been determined. The female in laying its egg inserts its egg-laying apparatus into the hole in the berry made and left open by the fruit worm. This parasite was never seen to drive its egg-laying apparatus through one of the white silken curtains which the worm usually makes over the mouth of its hole after going into its first or second berry. The life-history of this parasite has not yet been worked out to any extent. It is certainly a far less important enemy of the fruit worm than is *Phanerotoma tibialis*.

A large quantity of wormy berries was collected in August for the purpose of making a detailed study of some of the immature stages of these parasites, particularly of *Phanerotoma tibialis*.

Study of Control for Flowed Bogs.

No very definite advance in our ideas concerning the control of this pest by flooding was made during the year. The recommendations given in last year's report still stand with no substantial alteration. It was suspected that the depth of the flowage had some bearing on its effect in killing the worms within their cocoons, as it seemed reasonable to suppose that the greater water pressure of a deep flowage would be more effective in collapsing or penetrating the cocoons than would be the slight pressure of a shallow flowage. To test this, different lots of fruit worms, spun up naturally in their cocoons, were submerged to various depths in water contained in long glass tubes 2 inches in diameter. The following table, showing the results of some of these tests, is self-explanatory: —

Table 6.

Date submerged.	Date taken from Water.	Number submerged.	Depth of Submergence (Inches).	Cocoons occupied after Submergence.	Cocoons unoccupied after Submergence.	Number of Worms found Alive.	Number of Worms found Dead.
Oct. 8, 6 P.M.	Oct. 17, 5 P.M.	12	19	10	2	10	-
Oct. 8, 6 P.M.	Oct. 17, 5 P.M.	12	40	11	1	10	1 (?)
Oct. 8, 6 P.M.	Oct. 17, 5 P.M.	12	56	12	-	10	1[1]
Oct. 8, 6 P.M.	Oct. 17, 5 P.M.	12	68	12	-	10	2
Oct. 8, 6 P.M.	Oct. 17, 5 P.M.	9	80	9	-	8	1

It will be seen from this table that nine days of submergence, after the 8th of October, appeared to have but little effect on the worms at any depth tested. The remaining tests, not recorded in this table, gave results entirely similar. Possibly submergence earlier in the season would have been more effective in killing the worms. Bogs bearing late varieties could probably not, however, as a rule, be reflowed, after picking, before September 25, and it hardly seems probable that a difference of two weeks in the season would be sufficient to cause any marked difference in the effects of submergence on this insect. It may, of course, be possible to work in a flooding between the picking of the early and of the late varieties, but general experience appears to cast doubt upon the advisability of such a program.

An interesting fact learned while making these submergence tests was that the cocoons of the fruit worm are not at all impervious to water. When carefully opened, after only a few minutes' submergence, they were found to be wet inside, the water having apparently penetrated them almost immediately. It now seems evident that the cocoon protects the

[1] And 1 doubtful.

worm by preventing the escape of the vesicle of air which it contains, which the worm needs more than anything else in order to survive, rather than by keeping out the water by any imperviousness of its texture.

Study of Control for Dry Bogs.

The sanding experiment conducted last year to determine whether this insect could be smothered in its cocoon was repeated and continued this year on the same heavily infested bog, but the general results were unsatisfactory. It now seems pretty certain that this method of treatment for this insect will never be practicable.

In last year's report suggestions were made concerning the possibility of starving out fruit-worm infestations on dry bogs by killing the remnant of the bloom, in seasons of severe winter-kill injury or of severe frost damage, by spraying with a 20 per cent. solution of iron sulphate. First tests of the practicability of this method of treatment were made this year, and it was found that this solution can be used in such a way as to kill the bloom without apparent injury either to the vines or to the buds forming for the succeeding year's growth. It was necessary, however, to apply three rather thorough sprayings to accomplish the entire destruction of the blossom, because of the fact that the blossoming does not all take place at one time but is extended through a period of three or four weeks. The necessity of three sprayings instead of one has brought in a new element of danger which must be considered in connection with the practicability of this treatment. In making the 20 per cent. solution of iron sulphate 100 pounds of the chemical are used to every 50 gallons of water. It takes not less than 150 gallons to spray an acre thoroughly. This means that with each application 300 pounds of the iron sulphate would be put on each acre. Three applications would therefore deposit nearly half a ton of this chemical, per acre, on the bog. It seems probable that this amount of iron sulphate might injure the cranberry root system and perhaps kill the vines. Further experiments to determine about this are planned. If there proves to be no danger in this way, it seems probable that this method of treatment may be used to advantage on dry bogs.

8. WEEDS.

Horse-tail (*Equisetum* spp.) is one of the most troublesome weeds with which the cranberry grower has to contend. In general the growers show more concern over this weed than they do about any other. For this reason some attention was given to experimenting with it during the year. Solutions of copper sulphate as strong as 1 pound to 25 gallons of water were injected into a bog where this weed was growing in abundance to depths ranging from 6 inches to 2 feet, the solution being poured into holes a foot apart each way, made with a crow bar, a quart of the solution being used in each hole. Unfortunately, this treatment did not seem to affect the horse-tail injuriously, but rather seemed to cause it to thrive instead.

Thorough spraying with a 20 per cent. iron sulphate solution was fairly effective in killing back the tops of the weed, but there is, as has been already noted under the fruit-worm discussion, a possible danger connected with the continued use of this chemical on the same area.

9. RESANDING.

Plots O and V, spoken of in last year's report, were again left without resanding this year, while the surrounding bog was also not resanded. Three new plots, N, R and T, were laid out and resanded on Oct. 17, 1912, while the surrounding bog was not resanded again. All these plots were picked with scoops in 1913, and checks on each were laid out and picked for comparison. The following table is, in this connection, self-explanatory: —

TABLE 7.

PLOT.	Area of Plot (Square Rods).	Date picked.	Quantity of Fruit obtained (Bushels).	Percentage of Loss in Storage Tests.	Variety.
O, ...	9	Sept. 8	12½	29⅖	Early Black.
O (check 1), ...	9	Sept. 8	15	28 9/10	Early Black.
O (check 2), ...	9	Sept. 8	19½	–	Early Black.
V, ...	9	Sept. 6	18⅙	36¾	Early Black.
V (check 1), ...	9	Sept. 6	22	41 2/10	Early Black.
V (check 2), ...	9	Sept. 6	18⅔	–	Early Black.
N, ...	9	Sept. 4	20	38¼	Early Black.
N (check 1), ...	9	Sept. 4	15⅙	30 1/7	Early Black.
N (check 2), ...	9	Sept. 4	25	–	Early Black.
N (check 3), ...	9	Sept. 4	23½	–	Early Black.
R, ...	9	Sept. 9	17	36	Early Black.
R (check 1), ...	9	Sept. 9	16¾	34 2/10	Early Black.
R (check 2), ...	9	Sept. 9	18	–	Early Black.
T, ...	9	Sept. 28	20½	38¾	Howe.
T (check 1), ...	9	Sept. 28	19	29⅖	Howe.
T (check 2), ...	9	Sept. 28	23	–	Howe.

It will be seen from the above table that plots O and V showed a distinct falling off in quantity of fruit, due to the prolonged lack of resanding. Plots N, R and T, however, gave no increase in fruit over their checks, probably because the previous resanding of the general bog (fall of 1911) was still sufficient to maintain the vines in very good condition. Berries from all these plots and their checks were tested for keeping quality, the period of storage extending from October 28 to about December 20 on the average, there being a variation of five days in the time of final screening,

with the results given in the above table. The berries of the checks on each plot were mixed so as to have a single storage check in each case. The check storage figures given in the table, therefore, represent the mixture rather than the first check alone with which they are in each case associated. As the table shows, the berries of the unsanded plots, O and V, kept somewhat better on the average than did those of their checks, while the berries of the sanded plots, N, R and T, all showed a poorer keeping quality than did those of their checks. The results of these tests, therefore, substantiate the findings of last year.

10. MISCELLANEOUS.

During the fall the possibility of introducing cranberry vines for holiday decorations for dining rooms was investigated. A patch of Late Howe vines was left unpicked and was so protected from frost until into November, by covering with canvas, that it kept in good green condition. Some of these vines were cut and several wreaths and other decorations, bearing the natural fruit, were made from them, a damp moss foundation being used in every case. From the standpoint of beauty these decorations probably could not be easily surpassed, and there seemed for a time to be a considerable promise of success for them. It was found eventually, however, that even though plunged in wet moss the vines did not endure the heat of warm rooms for more than two or three days before they deteriorated badly in appearance. It became evident, therefore, that cranberry vines could not be used successfully in this way. Possibly, however, a satisfactory decoration could be made up by putting them in gold-fish jars for table ornamentation.

The results of the following spraying tests are of general interest, the spray in every case having been applied on a cranberry bog on the 29th of July: —

1. Plot sprayed with a mixture made up as follows: copper sulphate, 2 pounds; lime, 1½ pounds; resin fish-oil soap, 1 pound; arsenate of lead, 3 pounds; water, 25 gallons. No injury was later observed to have been caused by the application of this spray.

2. Plot sprayed with a mixture made up as follows: lime, 1½ pounds; resin fish-oil soap, 2 pounds; arsenate of lead, 3 pounds; water, 25 gallons. No injury was observed as a result of this application.

3. Plot sprayed with the following mixture: resin fish-oil soap, 2 pounds; arsenate of lead, 3 pounds; water, 25 gallons. The vines on this plot were badly burned by the treatment.

The interesting point shown by these three tests is that resin fish-oil soap and arsenate of lead cannot safely be used together as a spray unless lime is added. This confirms the general result of tests made in previous years, but not reported upon.

A plot was picked by hand in the three years 1911, 1912 and 1913 successively, the quantity of fruit it produced in comparison with the sur-

rounding bog being carefully noted each year, the general result being that no distinct advantage was shown for hand picking, from the standpoint of the quantity of fruit obtained.

The Station Bog Crop.

The bog bore a heavy crop this year, averaging about 100 barrels to the acre. This was probably largely due to the rest which the vines obtained because of last year's light crop. More water was pumped for irrigation this year than in 1912, but on the whole the bog was nevertheless run fairly dry throughout the season, the ditches not being held full of water for more than a day or two at a time. There is probably a limit beyond which a bog may become too dry if it is not irrigated. It seems probable that the wisest course to pursue, in irrigating a bog during the growing season, is to try to be sure that it has what water it needs, but that it is not given moisture much in excess of its needs. It is probably better to give a bog a good wetting occasionally and then draw off the surplus water, so that the ditches shall be fairly empty, than it is to keep the ditches full for any considerable period of time during the growing season and so run the risk of injuring the root system. The year's observations have confirmed those of last year in showing that the higher and better drained portions of a bog usually produce more fruit than the low portions. Blocks of vines from different parts of flowed and dry bogs were cut out during the season, and their root systems were washed out and examined, it being discovered from this that, while on dry bogs there is often a well-developed root growth running deep into the peat, the root system of flowed bogs is apparently always confined for the most part to the sand above the peat. It seems likely that this condition on the flowed bogs has been brought about by root drowning caused by holding the water table too high during periods of root growth. A mere examination, therefore, of the amounts of fruit borne by high and low portions of a bog is probably not sufficient to justify any certain conclusion concerning the causes of differences noted in the amount of fruit produced, for while a season's drainage is one possible important factor, the development of the root system, brought about by the conditions of previous seasons, is perhaps as likely to have a powerful influence on the ability of the plant to withstand drought, and therefore produce fruit under extreme conditions.

A Needed Investigation.

We are coming to understand something of the factors bearing directly on the portion of the cranberry plant which is above ground. While it is important to understand these more easily observed agencies bearing on the welfare of the plant, it seems certain that some of the most important things which influence cranberry growth and fruiting have been almost entirely neglected in our studies up to the present time. A knowledge of the special physiology of the plant, especially of the development and activities of its root system, seems to be very greatly needed. The sea-

sonal development of the root system of most plants begins fairly early in the spring and is nearly coincident with the development of the portions of the plant above ground. Recent investigations [1] by Professor Coville, of the Bureau of Plant Industry of the United States Department of Agriculture, have shown that with the blueberries, which are closely related to the cranberry, there is no new root growth until the plants have developed both their leaves and their blossoms. If this is also the rule in the development of the cranberry, it may have a rather vital bearing on the practices to be observed in the flooding and irrigation of cranberry bogs. A lot of vines have already been potted in earthen pots for this and other studies, and it is planned to pot more in glass pots, so that the growth of the root system may be directly observed in all its stages and in all seasons.

NOTES ON THE WATER OF CRANBERRY BOGS.[2]

Since 1910 the experiment station has been studying the properties and movements of the water in cranberry bogs, in order to determine the probable losses of fertility in the drainage water, because the bogs are generally flooded throughout the winter and sometimes for brief periods during the summer, as a protection against frost and insects.

The problem of fertilizing cranberry bogs to improve the crop is complicated by this periodical flowage and drainage. Many cranberry growers think that fertilizers are wasted if applied to the bogs, while actual field experiments in Massachusetts, New Jersey and Wisconsin have shown a positive benefit by a light top-dressing of soluble chemicals, namely, nitrates, superphosphates and potash salts.

The small experimental cranberry bogs in which the studies have been made were devised by Director Brooks, who has described them fully elsewhere.[3] It is deemed sufficient for this article to say that each bog is contained in an upright cylinder 24 inches in diameter and 48 inches in depth, constructed of glazed sewer tile bedded in concrete. Each bog is connected by a brass pipe passing through the concrete, with a smaller cylinder of similar construction, 6 inches in diameter and of the same depth as the bog. The small tile corresponds to the drainage ditch in the field, and is provided with an outlet and stopcock 12 inches below the level of the surface of the bog. By means of the smaller cylinder the bog can be drained or irrigated at will, and the depth of the water-level below the surface can be observed at any time.

At the approach of winter the bogs are fitted with galvanized iron rims cemented in place with an asphaltum cement, by which the water-level over the bogs may be raised to a height of about 12 inches. To prevent freezing and bursting the cylinders the entire set of bogs is covered with a

[1] Experiments in Blueberry Culture," by Frederick V. Coville, 1911. Bulletin No. 193 of the Bureau of Plant Industry, United States Department of Agriculture.

[2] By Fred W. Morse.

[3] Proc. Soc. Promotion Agri. Sci., 1911, pp. 23-28.

removable roof of boards which is further covered by cornstalks and hay to a depth sufficient to completely protect the interior from external temperature. As soon as freezing weather is over in the spring the covering of litter is removed, and later, at the proper season for draining the bogs, the roof is taken away.

The drainage from a cranberry bog consists of two quite distinct portions, namely, the run-off from the surface and the seepage from the soil, while there is the ditch water at the beginning of drainage, which is a mixture of both kinds. On a properly graded bog nearly all the surface flowage should run directly into the ditches without seeping through the soil. On the other hand, water retained by the vines and in depressions in the surface of the bog, together with the water held in the pore-space of the sand and peat above the level of the sluice gates, must either evaporate or sink lower into the bog, and as it settles it displaces the saturated bog water, which seeps into the ditches.

The composition of the three types of drainage water has been carefully followed season by season, and it is believed that some light has been obtained on the probable losses of fertility.

The surface water is removed from the experimental bogs by means of a dipper, because their construction does not permit it to be drawn off otherwise without losing its identity. Its composition has been found to be essentially like any surface water from ponds and streams. The surface waters from four bogs that had been top-dressed with a complete fertilizer in 1911 were examined in the spring of 1912, in comparison with the surface water from four bogs which had received no fertilizer. Total solids and organic solids were first determined with the following results: surface water contained in 100,000 parts, 16.0 parts total residue and 4.8 parts organic matter from the fertilized bogs while the surface water from the unfertilized bogs contained 19.2 parts total residue and 6.4 parts organic matter. No nitrates were found, and as the fertilized bogs had not imparted any increase of soluble matter to their flood waters it was not deemed worth while to carry the analysis further. The run-off cannot be considered as removing from the bogs any serious amount of fertility, since its composition cannot vary widely from the water when applied, except for the soluble matter that is extracted from the vines.

The water standing in the small cylinders at the time the surface water was dipped from the bogs is nearly the counterpart of the ditch water after the run-off has past and seepage begins. That is, it is a mixture of surface water and seepage water. A number of analyses have been made of the water at this stage, because there are possibilities for considerable variation, and it will be noted in the table that there is a wide range between the two seasons.

TABLE 1. — *Composition of Ditch Water.*

[Parts in 100,000.]

Bog.	May 4 and 9, 1912.		
	Total Residue.	Organic Matter.	Total Nitrogen.
8 (A and B),	71.1	38.6	1.42
9 (A and B),	64.3	33.6	1.38
14 (A and B),	56.2	26.2	1.15
15 (A and B),	52.3	26.3	1.36

Bog.	May 8 and 9, 1913.			
	Total Residue.	Organic Matter.	Total Nitrogen.	Potash.
4 (A and B),	37.0	12.2	0.28	-
5 (A and B),	38.0	11.4	0.40	3.8
6 (A and B),	40.4	10.8	0.56	3.1
7 (A and B),	56.2	15.2	0.90	4.6
8 (A and B),	60.6	14.4	0.91	4.7
9 (A and B),	46.8	13.0	0.45	3.6
10 (A and B),	65.2	17.4	0.56	-
12 (A and B),	56.8	15.8	0.91	-

To estimate the probable losses from a bog it would be necessary to know the capacity of the ditches, since the small cylinders in our experiments bear a much larger proportion to the bog's surface than occurs in field practice.

The average content of nitrogen in the ditch water was 1.33 parts in 100,000 in 1912, and 0.62 part in 100,000 in 1913. Potash was determined only in 1913, when the average content was 3.96 parts in 100,000. Fifty thousand gallons of ditch water, containing 0.98 part of nitrogen and 3.96 parts of potash in 100,000 parts of water, would carry away a trifle more than 4 pounds of nitrogen and 16 pounds of potash. It would also be equivalent in volume to the water contained in a ditch 3 feet deep, 2 feet wide and a little over 67 rods long, which would be more ditch than is usually employed on an acre of cranberry bog.

The mixture of surface and seepage water in the small cylinder of the experimental bogs may or may not closely resemble similar water in the ditches of large bogs. It is the writer's opinion that the latter water would be even more dilute, since a sample of ditch water collected at the

experimental bog in East Wareham contained only 21.3 parts of total solids and 12.1 parts of organic solids in 100,000 parts of water at a time when Dr. H. J. Franklin, the superintendent of the bog, deemed the ditch water to be at its normal state, with no irrigation water mixed with it. There was but 0.28 part of total nitrogen in 100,000 parts, and bare traces of phosphates and potash in this water.

The seepage water, which is practically the same thing as the saturated soil water from the interior of the peat, is noticeably uniform in composition throughout the season, and the average composition for 1912 is very close to that of 1911, published in the twenty-fourth annual report.[1]

TABLE 2. — *Composition of Seepage Water, 1912.*

Total Residue and Organic Matter.

[Parts in 100,000.]

Bog.	May 14.		May 22.		June 10.		June 17.	
	Total Residue.	Organic Matter.	Total Residue.	Organic Matter.	Total Residue.	Organic Matter.	Total Residue.	Organic Matter.
8 (A and B),	101.0	53.0	114.8	52.0	-	-	109.4	60.6
9 (A and B),	91.4	50.6	118.4	54.2	-	-	114.0	63.4
10 (A and B),	119.4	62.8	144.5	75.1	-	-	132.0	74.4
12 (A and B),	95.0	51.0	111.4	51.4	113.0	62.8	-	-
13 (A and B),	98.6	52.0	124.2	59.2	91.8	63.4	-	-
14 (A and B),	102.0	50.2	137.2	76.0	134.6	67.2	-	-
15 (A and B),	105.5	54.4	122.1	62.7	104.2	57.2	120.0	67.4

Fertility Constituents.

[Parts in 100,000.]

Bog.	Total Nitrogen.					Phosphoric Acid.		Potash.	
	May 14.	May 22.	June 10.	June 17.	June 25.	May 22.	June 10.	May 22.	June 10.
8 (A and B), .	2.45	3.04	-	2.66	-	-	-	-	-
9 (A and B), .	2.13	3.08	-	2.52	-	-	-	-	-
10 (A and B), .	3.01	3.96	-	3.36	3.38	-	1.78	7.75	-
12 (A and B), .	2.27	3.15	2.94	-	3.05	1.19	1.55	7.44	-
13 (A and B), .	2.38	3.22	2.90	-	2.69	1.17	-	7.29	6.15
14 (A and B), .	2.27	3.32	-	-	3.01	1.14	1.48	-	8.12
15 (A and B), .	2.59	3.43	3.32	2.73	-	-	2.00	-	6.62

[1] Mass. Agr. Sta., 24th An. Rept., Pt. I., p. 220.

The amount of this seepage must vary from season to season. The spring seasons of 1912 and 1913 were unusually wet for about three weeks after the surfaces of the bogs were drained, and several rains made it necessary to open repeatedly the stopcocks in the drainage cylinders. The amount of seepage determined by the amount of water which flowed through the outlets amounted to 25.6 quarts per bog in 1912 and 24.5 quarts in 1913, or, in round numbers, a little over 90,000 gallons per acre in the first year and over 85,000 gallons in the second, or an average weight of over 700,000 pounds of water per acre, which would contain, discarding fractions, more than 21 pounds nitrogen, 10 pounds of phosphoric acid and 50 pounds of potash.

There was no evidence that the application of fertilizers in the previous year caused any increase in these substances.

Fertilizer Scheme for Bogs.

Bogs numbered 6, 10, 11 and 14 receive no fertilizers.
Bog numbered 1 received nitrate of soda.
Bog numbered 2 received acid phosphate.
Bog numbered 3 received sulfate of potash.
Bog numbered 4 received nitrate and phosphate.
Bog numbered 5 received nitrate and potash.
Bog numbered 7 received phosphate and potash.
Bogs numbered 8, 9, 12, 13 and 15 receive all three substances.

The period of seepage was succeeded in both seasons by a short space of time during which the water-level fluctuated within narrow limits, and following this interval was a prolonged dry season during which it was necessary to add water repeatedly to the small cylinders to replace the amount of water evaporated from the surface of the bogs. The addition of this water gradually changed the composition of the water in the cylinders until it showed that practically all of the original seepage water had been reabsorbed by the peat. This showed that there was no apparent diffusion from bog to cylinder, and there must be actual movement of water from the bog to cause any loss to the bog of its soluble matter.

The permanent losses of fertility are limited to the seepage water which actually flows away from the ditches into the main drain or stream passing through a bog. They cannot be avoided; but there is no evidence that the small additions of chemicals in the late spring increase the losses any.

The amount of water required for irrigation was determined in both years by measuring the quantities added from time to time to the small cylinders. These cylinders were kept covered with galvanized iron caps, so that evaporation and rainfall would affect only the surface of the bogs. Water was added on seven different dates in the summer of 1912, beginning with July 3 and ending on August 16. In 1913 there were eleven different dates, beginning with June 19 and ending on August 28.

The total amount added in 1912 was 13.75 gallons per bog, equivalent to a depth of 7 inches over the surface, while in the yet drier season of 1913, 23.75 gallons were required per bog, or a depth of 12 inches.

During 1912 it was noticeable that some bogs evaporated much more rapidly than others; but the actual differences were not determined. In the fall, before putting on the sheet-iron rims, it was necessary to cut off the vines which extended over the wall of the tile, and also to cut out some of the surplus growth within the bog area. These prunings were dried and weighed, and were found to vary much. There also appeared to be some relationship between the weight of prunings and the rate of water movement in the bogs, which was to be expected, since transpiration should increase with the development of the vines.

Therefore in 1913 a careful record was kept of the amounts of water removed from individual bogs as drainage water in the spring and the quantities of irrigation water added during the summer. The results, together with the weight of vines removed the previous fall, are given in Table 3, as follows: —

TABLE 3. — *Relation between Drainage, Irrigation and Vine Growth.*

Bog.	Drainage (Quarts).	Irrigation (Quarts).	Vines (Grams).	Bog.	Drainage (Quarts).	Irrigation (Quarts).	Vines (Grams).
6A, . .	25.1	88.0	190.7	6B, . .	21.5	103.0	184.2
10A, . .	21.0	98.0	187.1	10B, . .	28.5	107.0	295.8
14A, . .	19.5	95.0	185.2	14B, . .	18.4	85.0	140.5
11A, . .	3.1	64.0[1]	38.0	11B, . .	23.5	96.0	184.3
2A, . .	28.9	102.0	123.2	2B, . .	30.0	113.0	221.7
3A, . .	24.5	100.0	165.4	3B, . .	28.9	120.0	238.9
7A, . .	22.9	85.0	124.1	7B, . .	28.2	114.0	298.3
1A, . .	10.8	85.0	98.5	1B, . .	6.4	62.0	91.4
4A, . .	32.0	117.0	258.9	4B, . .	31.3	117.0	302.1
5A, . .	28.1	101.0	213.9	5B, . .	23.3	96.0	216.6
8A, . .	23.6	89.0	186.8	8B, . .	25.6	98.0	226.6
9A, . .	23.3	83.0	187.8	9B, . .	24.8	93.0	221.8
12A, . .	27.1	100.0	252.5	12B, . .	28.3	103.0	235.4
13A, . .	25.3	92.0	173.3	13B, . .	25.6	93.0	214.3
15A, . .	30.9	93.0	231.2	15B, . .	22.9	85.0	173.0

Excluding 1A, 1B and 11A, the averages for 27 bogs are: drainage, 25.6 quarts; irrigation, 98.7 quarts; vines, 208.8 grams.

The bogs are arranged so that the unfertilized ones, 6, 10, 11 and 14, head the columns, followed by 2, 3 and 7 with no nitrogen, while 1, 4 and 5 receive nitrogen in nitrate of soda, and 8, 9, 12, 13 and 15 are dressed with complete fertilizers, including nitrates.

It will be noted that neither nitrogen nor other fertilizers were responsible for large vine growth, but that in 12 out of 14 bogs having vine

[1] Water applied to surface of bog.

growth above the average, the drainage from the bogs in the spring was above the average, and in 10 cases the irrigation was high also. On the other hand, bogs 1A, 1B and 11A, in which the water movement was notably slow, yielded the smallest weights of vines when pruned.

In a large proportion of the bogs the growth of vines appeared to be related to the freedom with which the soil permitted the water to move from bog to drain and back again. Not only was more water evaporated during the summer, but these bogs permitted rapid percolation or seepage in the spring into the small cylinders. The bogs with small vine growth were slow to drain in the spring, and much of the water evaporated from the surface of the bog instead of seeping into the drainage cylinder.

In conclusion our observations show that the principal losses of fertility are in the seepage water which may escape from the ditches, and that the vine growth is more influenced by the free movement of water than by fertilizers.

The assistance of Mr. R. W. Ruprecht in measuring the water, and of Mr. R. L. Coffin in pruning and weighing the vines, is gratefully acknowledged.

THE DETERMINATION OF ACETYL NUMBER.[1]

EDW. B. HOLLAND.

Introduction.

The various hydroxy compounds that occur in oils, fats and waxes form derivatives on heating with acetic anhydride, the acetyl radical displacing the hydrogen of the alcoholic hydroxyl groups. This property serves as the basis of analytical methods for the quantitative determination of these compounds. The proposed acetyl number indicates the milligrams of potassium hydroxide required for the saponification of the acetyl assimilated by one gram of an oil, fat or wax on acetylation.[2] On saponifying with alcoholic potash the acetyl is hydrolyzed to acetic acid and combines with the alkali to form potassium acetate. The results are expressed in terms of milligrams of potassium hydroxide to conform with the general practice in fat analysis. The compounds involved are monohydroxy and dihydroxy acids and their glycerides, — monoglycerides and diglycerides and free alcohols.

Use of the Test.

In the examination of oils and fats a determination of acetyl number is necessary, in most instances, for a thorough understanding of the nature and quality of the product. Some of the hydroxy compounds are natural and others are the result of hydrolysis or of oxidation. Glycerides of hydroxy acids are a natural constituent of certain oils and fats, although they do not appear to be very widely distributed in any considerable amount. Castor oil, composed largely of ricinolein, is a notable illustration. Hydroxy acids probably occur more frequently as the result of oxidation of unsaturated acids. Oleic acid has been shown repeatedly to be comparatively unstable. By the assimilation of oxygen and water it may be converted into dihydroxystearic acid, a saturated compound.

$$C_{17}H_{33}COOH + H_2O + O = C_{17}H_{33}(OH)_2COOH.$$

Whether the oxidation takes place in the glycerides or in the fatty acids after hydrolysis is uncertain, although the latter appears the more probable supposition.

Monoglycerides and diglycerides result from the hydrolysis of triglycerides, and free fatty acids condition their presence. The absence of

[1] The writer is pleased to acknowledge many suggestions and helpful criticisms by Dr. J. S. Chamberlain, Mr. F. W. Morse, Mr. J. C. Reed and Mr. J. P. Buckley.

[2] Benedikt and Ulzer, and Lewkowitsch report on the basis of the acetylated product.

free fatty acids in a commercial product, however, does not necessarily preclude the presence of monoglycerides and diglycerides.

Solid alcohols of the cyclic series (sterols) occur in oils and fats both in combination as esters and as free alcohols.[1] The amount of cholesterol or phytosterol is generally small, often inappreciable, and is indicated approximately by the unsaponifiable matter which it characterizes. Alcohols of the ethane and other series, free and in combination, compose a considerable proportion of waxes.

Oils and fats, therefore, may contain glycerides of monohydroxy and dihydroxy acids, possibly free hydroxy acids, monoglycerides and diglycerides and free alcohols; and the insoluble acids, separated from the oils and fats, may contain monohydroxy and dihydroxy acids and free alcohols. A portion, at least, of the free alcohols found in the insoluble acids probably occurred in the fat as esters. With the exclusion of the natural glycerides of hydroxy acids and a small amount of free alcohols, the acetyl number of many oils and fats may be deemed an index of quality, and when considered in conjunction with the acid and iodine numbers may serve to measure (more or less imperfectly, to be sure) the amount of hydrolysis and of oxidation the product has undergone. To differentiate between products of hydrolysis and of oxidation the acetyl number of the insoluble acids should also be determined.

Earlier Methods.

The several analytical processes that have been offered are based on the same chemical reactions, but differ in application and in details of procedure. The original method was devised by Benedikt and Ulzer[2] and applied to the insoluble acids. The acetyl number indicated the milligrams of potassium hydroxide required to neutralize the acetic acid obtained on saponifying one gram of acetylated insoluble fatty acids, and was determined by the difference between the acid and saponification numbers of the acetylated acids (acetyl ether number). The actual procedure consisted in saponifying the acetylated acids after neutralizing in alcohol. Lewkowitsch[3] has shown, however, that the results so obtained were generally in excess of the true values, due to the conversion of a part of the fatty acids on heating with a large excess of acetic anhydride into their anhydrides, as illustrated by the following equation: —

$$\underset{\text{fatty acid}}{2\,RCOOH} + \underset{\substack{\text{acetic}\\\text{anhydride}}}{(CH_3CO)_2O} = \underset{\substack{\text{anhydride of}\\\text{fatty acid}}}{(RCO)_2O} + \underset{\text{acetic acid}}{2\,CH_3COOH}$$

These fatty anhydrides are fairly stable compounds, but may become hydrolyzed to some extent on washing with boiling water. Subsequent treatment with cold alcohol in the determination of the acetyl acid

[1] See numerous references: Abderhalden, Physiological Chemistry (1908); Hammarsten, Physiological Chemistry (1911); Leathes, The Fats (1910).

[2] Monatsh. Chem., 8, pp. 41–48 (1887).

[3] Analysis of Oils, Fats and Waxes, 1, pp. 344, 345 (1909).

number will continue the hydrolysis, although a portion is likely to remain unchanged, thereby yielding too low an acid number, due to the inability of the anhydrides to combine with alkali. As complete hydrolysis occurs on saponification, the acetyl (ether) number would be too high and even appear when none exists.

Lewkowitsch[1] proposed the acetylation of the natural product. In conformity thereto the acetyl number indicates the milligrams of potassium hydroxide required for the neutralization of the acetic acid obtained on saponifying one gram of an acetylated oil, fat or wax. This method requires the saponification of the acetylated fat and the determination of the resulting acetic acid by either a filtration or distillation process. The former process is an adaptation of the regular method for the direct determination of soluble acids, and the latter process is a modified Reichert-Meissl test, with repeated distillation of the aqueous solution until the distillate is free from acids. The presence of natural soluble or volatile acids necessitates a similar treatment of the unacetylated fat in order to determine the amount of alkali assimilated by those acids for which proper corrections must be made to obtain the true acetyl number. The occurrence of the lower acids makes the determination a long and tedious operation.

Proposed Method.

Analytical methods for the examination of oils and fats is a subject that has been given considerable study by the writer in connection with feeding experiments and other investigations made at the Massachusetts Agricultural Experiment Station. During the past few years the determination of acetyl number has received particular attention with a view to evolving a process that might be free from the objections cited for the Benedikt and Ulzer, and Lewkowitsch methods. Believing that this end has been attained in some measure, a report of progress is now offered in the hope that it may lead to further improvement.

The custom of reporting acetyl number on the basis of the acetylated product appears unwarranted. It is contrary to general practice in analytical work and is the exception in fat analysis. The definition[2] here adopted places the acetyl number on a par with other tests, and is as follows: the acetyl number indicates the milligrams of potassium hydroxide required for the saponification of the acetyl assimilated by one gram of an oil, fat or wax on acetylation.

Method in Detail.

The development of the method extended over a period of several years, and finally resolved into an adaptation of several well-known processes. For instance, ceresine is used to solidify the acetylated fat so that it may be washed by decantation as in the determination of insoluble

[1] *Loco citato*, 1, pp. 337, 338 (1909).

[2] The hydroxyl value of Twitchell is reported in a similar manner. Jour. Amer. Chem. Society, 29, pp. 566–571 (1907).

acids. The saponification number of the acetylated fat is determined by the same process as that of the original fat, and the difference measures the amount of acetyl that has been assimilated. The process may be appropriately described as a method by analogy.

The reagents employed in the determination are summarized so that their application may be clearly understood: —

Acetic anhydride, Kahlbaum's.
Ceresine, pure white, filtered.
Alcohol, redistilled, free from acids and aldehydes.
Alcoholic potash, 50 c.c. of a saturated solution of potassium hydroxide, free from carbonate, to 1,000 c.c. of alcohol. The solution should be allowed to stand at least twenty-four hours and filtered immediately before use.
$N/_2$ hydrochloric acid.
Alkali blue (6B), 1 gram to 100 c.c. of alcohol. The indicator should be digested in a stoppered bottle for several days at room temperature, with occasional shaking, and then filtered.
Phenolphthalein, 1 gram to 100 c.c. of alcohol, neutralized.

After what has been said, the details of the method should be so evident as to require no further explanation.

Into a 300 c.c. Erlenmeyer flask are brought 5 grams of fat, together with 10 c.c. of acetic anhydride. The flask is connected with a spiral or other form of reflux condenser and heated in a boiling water bath (immersed in the water) for from one to one and one-half hours. Longer heating yields higher results, but is accompanied by partial decomposition of the fat with formation of aldehydes or other bodies that give a reddish color with caustic alkali. After acetylating, the flask is removed from the bath and sufficient ceresine added to form, with the fat, a solid disc when chilled in cold water. The amount of ceresine required will vary with the consistency of the product under examination. For butter fat .4 to .5 grams is ample; for softer fats and oils rather more; and for harder fats, less. The flask is heated on the water bath and the contents rotated until the ceresine and acetylated fat form a homogeneous mixture. One hundred and fifty c.c. of boiling water are then poured carefully into the flask with as little disturbance of the fat layer as possible, and the solution heated on the bath with occasional agitation to remove occluded acetic acid. The flask is immersed in cold water to solidify the ceresine-fat, after which the solution is decanted through a dense, ether-extracted filter, care being taken not to break the insoluble cake. Another 150 c.c. of boiling water are added, thoroughly agitated, heated as above, cooled and decanted, the process being repeated until the final filtrate gives a decided color with two or three drops of $N/_{10}$ alkali, using phenolphthalein as indicator (about six times). Prolonged washing is likely to cause slight dissociation of the acetylated product.

The filter and inverted flask containing the cake of ceresine-fat are allowed to drain in a cool place until practically dry. The small particles adhering to the filter are then scraped into the flask, and 50 c.c. of alcoholic potash, accurately measured with a burette, 50 c.c. of alcohol and several glass beads added. The flask is connected with a spiral or other form of reflux condenser and the solution boiled on a water bath until saponification is complete, — about sixty minutes. The flask is placed in a water bath at 60° C. and the solution, after cooling to that temperature, titrated with $N/_2$ hydrochloric acid, using 1 c.c. of alkali blue as indicator. Phenolphthalein may be employed, though less satisfactory for colored solutions. The alcoholic mixture is again brought to boil to free any alkali occluded in the ceresine, and retitered if necessary. Several blank determinations should

be run with every series of tests under precisely similar conditions as to time and treatment, except that the ceresine may be omitted. However, every lot of ceresine must be tested, should be free from soluble matter and not assimilate any alkali on saponification. The difference between the titration of the blank and that of the excess alkali in the test is the acid equivalent of the fat after acetylation, which should be calculated to milligrams of potassium hydroxide for 1 gram of fat.

One c.c. of $N/_2$ acid is equivalent to 28.054 milligrams of potassium hydroxide.

The difference between the saponification number of the fat before and after acetylation is the acetyl number. In case the original fat contains *free soluble* acids, their titer should be determined and proper correction made for the same.

Limit of error, 0.50 acetyl number.

Synopsis of Reaction.

A better conception of the method may be obtained by a summary of the reactions: —

Acetylation of glycerides of monohydroxy and dihydroxy acids, monoglycerides and diglycerides and free alcohols. (See formulas.)
Saponification of the acetylated product. (See formulas.)
Saponification of the original or unacetylated product.
Titration of excess alkali.
Acetyl number by difference.

Glycerides of Monohydroxy and Dihydroxy Acids.

Acetylation: —

$$\underset{\substack{\text{triglyceride of}\\\text{monohydroxy acid}}}{(R.OH.COO)_3C_3H_5} + \underset{\substack{\text{acetic}\\\text{anhydride}}}{3(CH_3CO)_2O} = \underset{\substack{\text{acetylated}\\\text{glyceride}}}{(R.OCH_3CO.COO)_3C_3H_5} + \underset{\substack{\text{acetic}\\\text{acid}}}{3\,CH_3COOH}$$

Example: Ricinolein $(C_{17}H_{32}.OH.COO)_3C_3H_5$

Saponification: —

$$\underset{\text{acetylated glyceride}}{(R.OCH_3CO.COO)_3C_3H_5} + \underset{\text{alkali}}{6\,KOH}$$
$$= \underset{\substack{\text{potassium}\\\text{salt of hydroxy acid}}}{3\,R.OH.COOK} + \underset{\substack{\text{potassium}\\\text{acetate}}}{3\,CH_3COOK} + \underset{\text{glycerol}}{C_3H_5(OH)_3}$$

$$\underset{\substack{\text{triglyceride of}\\\text{dihydroxy acid}}}{[R(OH)_2COO]_3C_3H_5} + (CH_3CO)_2O = \underset{\text{acetylated glyceride}}{[R(OCH_3CO)_2COO]_3C_3H_5} + H_2O$$

Example: Dihydroxystearin $[C_{17}H_{33}(OH)_2COO]_3C_3H_5$

$$[R(OCH_3CO)_2COO]_3C_3H_5 + 9\,KOH = 3\,R(OH)_2COOK + 6\,CH_3COOK + C_3H_5(OH)_3$$

Monoglycerides and Diglycerides.

$$\underset{\text{monoglyceride}}{(RCOO)C_3H_5(OH)_2} + (CH_3CO)_2O = \underset{\text{diaceto-glyceride}}{(RCOO)(CH_3COO)_2C_3H_5} + H_2O$$

$$(RCOO)(CH_3COO)_2C_3H_5 + 3\,KOH = RCOOK + 2\,CH_3COOK + C_3H_5(OH)_3$$

$$\underset{\text{diglyceride}}{(RCOO)_2C_3H_5(OH)} + (CH_3CO)_2O = \underset{\text{monaceto-glyceride}}{(RCOO)_2(CH_3COO)C_3H_5} + CH_3COOH$$

$$(RCOO)_2(CH_3COO)C_3H_5 + 3\,KOH = 2\,RCOOK + CH_3COOK + C_3H_5(OH)_3$$

Free Alcohols.

$$\underset{\text{monobasic alcohol}}{ROH} + (CH_3CO)_2O = \underset{\text{acetate of alcohol}}{CH_3COOR} + CH_3COOH$$

$$CH_3COOR + KOH = ROH + CH_3COOK$$

Examples: Cholesterol, phytosterol, $C_{27}H_{45}OH$

Considerable variation is possible in writing the above formulas which, at best, poorly express the structure. In some instances the reaction is indicated at some sacrifice of form.

Calculated Data from the Acetyl Number.

The acetyl number (c) serves to measure the amount of hydroxy compounds in an oil, fat or wax; and in case only one such compound of known molecular weight (m) and number of hydroxyls (d) is present, its amount (H) can be readily calculated by the following formula: —

$$H = \frac{cm}{56108\ d}$$

The derivation of the formula is comparatively simple. The theoretical acetyl number of a compound containing (d) hydroxyl groups is —

$$\frac{56108\ d}{m}$$

The amount of such a compound in an oil, fat or wax is, therefore —

$$\frac{c}{\dfrac{56108\ d}{m}} = \frac{cm}{56108\ d}$$

The same results may be calculated more easily from the following table, dividing the determined acetyl number by the theoretical acetyl number, or multiplying by its reciprocal: —

Acetyl Number on Original Product (Massachusetts Method).

Glycerides.

Name.	Formula.	Molecular Weight.	Saponification Number.	Theoretical Acetyl Number.	Reciprocal.
Ricinolein,	$(C_{17}H_{32}.OH.COO)_3C_3H_5$,	932.832	180.444	180.444	.0055419
Dihydroxystearin,	$[C_{17}H_{33}(OH)_2COO]_3C_3H_5$,	986.880	170.562	341.124	.0029315
Monoglycerides.					
Monopalmitin,	$(C_{15}H_{31}COO)C_3H_5(OH)_2$,	330.304	169.868	339.736	.0029435
Monostearin,	$(C_{17}H_{35}COO)C_3H_5(OH)_2$,	358.336	156.579	313.159	.0031933
Monolein,	$(C_{17}H_{33}COO)C_3H_5(OH)_2$,	356.320	157.465	314.930	.0031753

Acetyl Number on Original Product (Massachusetts Method) — Con.

Diglycerides.

Name.	Formula.	Molecular Weight.	Saponification Number.	Theoretical Acetyl Number.	Reciprocal.
Dipalmitin,	$(C_{15}H_{31}COO)_2C_3H_5(OH)$,	568.544	197.374	98.687	.0101330
Distearin,	$(C_{17}H_{35}COO)_2C_3H_5(OH)$,	624.608	179.658	89.829	.0111323
Diolein,	$(C_{17}H_{33}COO)_2C_3H_5(OH)$,	620.576	180.826	90.413	.0110604
Hydroxy Acids.					
Ricinoleic,	$C_{17}H_{32}.OH.COOH$,	298.272	188.110	188.110	.0053160
Dihydroxystearic,	$C_{17}H_{33}(OH)_2COOH$,	316.288	177.395	354.791	.0028186
Free Alcohols.					
Cholesterol,	$C_{27}H_{45}OH$,	386.368	–	145.219	.0068862
Phytosterol,	$C_{27}H_{45}OH$,	386.368	–	145.219	.0068862

Gravimetric Process.[1]

After acetylating, a gravimetric process for acetyl number may be conducted in a manner similar to that for the quantitative determination of insoluble fatty acids, observing all the precautions therein noted as to ceresine, washing, drying, weighing, etc.

This modification is apparently rather more difficult, tedious and subject to error than the saponification or volumetric process (Massachusetts method). A certain amount of loss arises from the dehydration of free fatty acids by acetic anhydride during acetylation, and is difficult to prevent, although of little consequence where the amount of free acids is relatively small.

The acetyl number (a) is calculated from the increase in weight (i) by the following formula: —

$$a = \frac{56108\,i}{42.016} \text{ or } 1335.39604\,i$$

In case only one hydroxy compound of known molecular weight (m) and number of hydroxyls (d) is present, its amount can be calculated from the increase in weight (i) of the oil, fat or wax on acetylating. The theoretical increase for a hydroxy compound is —

$$\frac{42.016\,d}{m}.$$

[1] This process has not received sufficient study in this laboratory to warrant positive statements, but is similar to the methods described by Lewkowitsch (*loco citato*), 1, pp. 358–363, 466, 467.

The amount (H) of such a compound in an oil, fat or wax is therefore —

$$H = \frac{i}{\frac{42.016\,d}{m}} \text{ or } \frac{im}{42.016\,d}$$

Molecular Weight of Hydroxy Compounds.

The molecular weight of the hydroxy compounds can be calculated from the weight (w) of fat taken and the increase (i) on acetylating, provided the number (d) of hydroxyls in the molecule is known: —

$$w : w+i = m : m+42.016\,d$$

$$m = \frac{42.016\,dw}{i}$$

The formation of anhydrides during the acetylating process will affect the accuracy of these calculations.

The computation of the amount of hydroxy compounds by the gravimetric process is greatly facilitated by use of the following table: —

Acetyl Gravimetric Process on Original Product.

Name.	Molecular Weight.	Molecular Weight after Acetylating.	Theoretical Increase in Weight per Gram on Acetylating.[1]	Reciprocal.
Glycerides.				
Ricinolein,	932.832	1058.880	.135124	7.40061
Dihydroxystearin,	986.880	1238.976	.255447	3.91471
Monoglycerides.				
Monopalmitin,	330.304	414.336	.254408	3.93069
Monostearin,	358.336	442.368	.234506	4.26428
Monolein,	356.320	440.352	.235833	4.24029
Diglycerides.				
Dipalmitin,	568.544	610.560	.073901	13.53162
Distearin,	624.608	666.624	.067268	14.86591
Diolein,	620.576	662.592	.067705	14.76996
Hydroxy Acids.				
Ricinoleic,	298.272	340.288	.140865	7.09900
Dihydroxystearic,	316.288	400.320	.265682	3.76390
Free Alcohols.				
Cholesterol,	386.368	428.384	.108746	9.19574
Phytosterol,	386.368	428.384	.108746	9.19574

[1] Acetyl number = 1335.39604 i.

Acetyl Number of Insoluble Fatty Acids.

The acetyl number of the insoluble fatty acids is determined by the Massachusetts method in precisely the same way as that of the original fat. The gravimetric process is not applicable on account of the formation of anhydrides of the fatty acids. The method for preparing the stock of insoluble acids for analysis is the same as that for the determination of "Insoluble Acids," with the elimination of such features as are necessary only for quantitative work.

In order to interpret the results satisfactorily it is necessary to know the percentage of insoluble acids so that the acetyl number of the acids may be considered in conjunction with the acetyl number of the fat.

Results by Different Methods.

For convenience, the theoretical acetyl numbers of some hydroxy compounds by the Benedikt and Ulzer, and Lewkowitsch methods are tabulated to permit comparison with the acetyl numbers by the Massachusetts and gravimetric processes previously stated. When only one hydroxy compound of known composition is present in an oil or fat the results can be readily converted from the basis of the original to that of the acetylated product and vice versa. In other cases conversion is generally impracticable on account of the marked differences in assimilation of acetyl by the several classes of hydroxy compounds. Formulas may show the relation, however, that the results by different methods bear to each other, (m) indicating the molecular weight of the hydroxy compound, (d) the number of hydroxyls, and (i) the increase in weight on acetylating: —

Massachusetts Method.

$$\frac{\mathrm{cm}}{56108\ \mathrm{d}}$$

Gravimetric Method.

$$\frac{\mathrm{im}}{42.016\ \mathrm{d}}$$

Benedikt and Ulzer, and Lewkowitsch Methods.

$$\frac{\mathrm{c(m + 42.016\ d)}}{56108\ \mathrm{d}}$$

Acetyl Number on Acetylated Product. (Benedikt and Ulzer, and Lewkowitsch Methods.)

Name (Acetylated).	Formula.	Molecular Weight.	Saponification Number.	Theoretical Acetyl Number.	Reciprocal.
	Glycerides.				
Ricinolein,	$(C_{17}H_{32} . OCH_3CO . COO)_3C_3H_5$,	1058.880	317.928	158.964	.0062907
Dihydroxystearin,	$[C_{17}H_{33}(OCH_3CO)_2COO]_3C_3H_5$,	1238.976	407.572	271.715	.0036803
	Monoglycerides.				
Monopalmitin,	$(C_{15}H_{31}COO)(CH_3COO)_2C_3H_5$,	414.336	406.250	270.833	.0036923
Monostearin,	$(C_{17}H_{35}COO)(CH_3COO)_2C_3H_5$,	442.368	380.507	253.671	.0039421
Monolein,	$(C_{17}H_{33}COO)(CH_3COO)_2C_3H_5$,	440.352	382.249	254.832	.0039242
	Diglycerides.				
Dipalmitin,	$(C_{15}H_{31}COO)_2(CH_3COO)C_3H_5$,	610.560	275.688	91.896	.0108819
Distearin,	$(C_{17}H_{35}COO)_2(CH_3COO)C_3H_5$,	666.624	252.502	84.167	.0118811
Diolein,	$(C_{17}H_{33}COO)_2(CH_3COO)C_3H_5$,	662.592	254.039	84.680	.0118092
	Hydroxy Acids.				
Ricinoleic,	$C_{17}H_{32}. OCH_3CO . COOH$,	340.288	329.768	164.884	.0060649
Dihydroxystearic,	$C_{17}H_{33}(OCH_3CO)_2COOH$,	400.320	420.474	280.316	.0035674
	Free Alcohols.				
Cholesterol,	$CH_3COO\ C_{27}H_{45}$,	428.384	–	130.976	.0076350
Phytosterol,	$CH_3COO\ C_{27}H_{45}$,	428.384	–	130.976	.0076350

Résumé.

The acetyl numbers of a fat and of the insoluble acids afford valuable information relative to the nature and the quality of a product. Apparently many analysts have been deterred from making the determinations on account of the time required, tedious manipulation involved or inability to interpret the results. The proposed method is comparatively short and simple and readily understood because of its similarity to other fat methods in common use. It is practically free from the objections cited for the earlier methods, and the results are directly comparable with other fat determinations, being on the same basis.

THE DIGESTIBILITY OF CATTLE FOODS.

BY J. B. LINDSEY AND P. H. SMITH.

FOREWORD.

The digestion experiments herein reported were made during the autumn, winter and early spring of 1910–11, 1911–12, 1912–13 and also, two experiments, in the autumn of 1913. They form part of what are known as Series XVI., XVII., XVIII. and XIX. The experiments made in these series and not here included have either been published in previous reports or will be found in later publications.

The usual method was employed and has been fully described elsewhere.[1] The full data are here presented, with the exception of the daily production of manure and the daily water consumption, in which cases, to economize space, averages only are given. The periods extended over fourteen days, the first seven of which were preliminary, collection of feces being made during the last seven. Ten grams of salt were given each sheep daily with water *ad libitum*. The sheep used in these experiments were grade Shropshires of substantially uniform weight, born in 1907.

1. SERIES XVI.

The hay used in connection with this series consisted of fine mixed grasses, and contained a large proportion of June grass (*Poa pratensis*). The digestion coefficients of this hay, as obtained in Period I., were applied to the two experiments on beet pulp which follow: —

[1] Eleventh report of the Mass. State Agr. Exp. Sta., pp. 146–149; also the 22d report of the Mass. Agr. Exp. Sta., p. 84.

Composition of Feedstuffs (Per Cent).

[Dry Matter.]

Feeds.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
English hay, Period I.,	7.47	9.58	30.98	49.36	2.61
English hay, Period II.,	6.96	9.90	31.39	49.13	2.62
English hay, Period III.,	6.66	9.64	30.76	50.46	2.48
Waste, Sheep I., Period I.,	8.89	5.86	36.92	46.94	1.39
Molasses dried beet pulp,	5.56	11.68	16.40	65.89	.47
Plain dried beet pulp,	3.29	8.12	20.46	67.76	.37

Composition of Feces (Per Cent).

[Dry Matter.]

Sheep I.

Period.	Feeds.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.	English hay,	13.61	11.82	25.82	45.49	3.26
II.	Molasses dried beet pulp,	13.15	15.27	24.46	43.03	4.09
III.	Dried beet pulp,	12.20	13.49	25.81	44.63	3.87
	Sheep II.					
I.	English hay,	13.37	11.13	28.27	44.32	2.91
II.	Molasses dried beet pulp,	13.67	15.69	25.10	41.87	3.67
III.	Dried beet pulp,	11.98	12.37	27.55	44.25	3.85

Dry Matter Determinations made at the Time of weighing out the Different Foods, and Dry Matter in Air-dry Feces (Per Cent).

Sheep I.

Period.	English Hay.	Molasses Dried Beet Pulp.	Dried Beet Pulp.	Waste.	Feces.
I.,	88.55	-	-	83.40	93.62
II.,	89.85	89.60	-	-	92.25
III.,	90.90	-	89.64	-	88.83
Sheep II.					
I.,	88.55	-	-	-	93.57
II.,	89.85	89.60	-	-	92.47
III.,	90.90	-	89.64	-	89.02

Average Daily Amount of Manure excreted and Water drunk (Grams).

Sheep I.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
I.	English hay,	627	27.600	1,512
II.	Molasses dried beet pulp,	684	23.470	1,893
III.	Dried beet pulp,	695	26.097	1,829
	Sheep II.			
I.	English hay,	1,032	30.768	2,465
II.	Molasses dried beet pulp,	983	24.881	2,611
III.	Dried beet pulp,	605	27.486	1,946

Weights of Animals for Two Days at Beginning and Two Days at the End of Period (Pounds).

Sheep I.

Period.	Character of Food or Ration.	Beginning.		End.	
		First Weight.	Second Weight.	First Weight.	Second Weight.
I.	English hay,	122.00	121.75	120.00	119.00
II.	Molasses dried beet pulp,	128.25	126.50	125.25	126.25
III.	Dried beet pulp,	126.25	127.00	125.25	125.00
	Sheep II.				
I.	English hay,	125.00	128.50	126.50	126.50
II.	Molasses dried beet pulp,	142.25	141.50	140.25	140.00
III.	Dried beet pulp,	140.75	139.75	138.50	138.50

English Hay, Period I.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed daily,	708.40	52.92	67.86	219.46	349.67	18.49
13.75 grams waste,	11.47	1.02	.67	4.23	5.39	.16
Amount consumed,	696.93	51.90	67.19	215.23	344.28	18.33
276.03 grams manure excreted,	258.42	35.17	30.55	66.72	117.56	8.42
Grams digested,	438.51	16.73	36.64	148.51	226.72	9.91
Per cent. digested,	62.92	32.24	54.53	69.00	65.85	54.06

English Hay, Period I — Concluded.

Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed daily,	708.40	52.92	67.86	219.46	349.67	18.49
307.68 grams manure excreted,	287.90	38.49	32.04	81.39	127.60	8.38
Grams digested,	420.50	14.43	35.82	138.07	222.07	10.11
Per cent. digested,	59.36	27.27	52.79	62.91	63.51	54.68
Average per cent. for both sheep,	61.14	29.76	53.66	65.96	64.68	54.37

Average nutritive ratio of rations for both sheep, 1:10.7.

Molasses Dried Beet Pulp, Period II.

Sheep I.

500 grams English hay fed,	449.25	31.27	44.48	141.02	220.71	11.77
300 grams molasses dried beet pulp fed,	268.80	14.94	31.40	44.08	177.12	1.26
Amount consumed,	718.05	46.21	75.88	185.10	397.83	13.03
234.70 grams manure excreted,	216.51	28.47	33.06	52.96	93.16	8.86
Grams digested,	501.54	17.74	42.82	132.14	304.67	4.17
Minus hay digested,	274.04	9.38	24.02	93.07	143.46	6.36
Molasses dried beet pulp digested,	227.50	8.36	18.80	39.07	161.21	-
Per cent. digested,	84.64	55.96	59.87	88.63	91.02	-

Sheep II.

Amount consumed as above,	718.05	46.21	75.88	185.10	397.83	13.03
248.81 grams manure excreted,	230.07	31.45	36.10	57.75	96.33	8.44
Grams digested,	487.98	14.76	39.78	127.35	301.50	4.59
Minus hay digested,	274.04	9.38	24.02	93.07	143.46	6.36
Molasses dried beet pulp digested,	213.94	5.38	15.76	34.28	158.04	-
Per cent. digested,	79.57	36.01	50.19	77.77	89.23	-
Average per cent. for both sheep,	82.11	45.99	55.03	83.20	90.13	-

Average nutritive ratio of rations for both sheep, 1:10.7.

Dried Beet Pulp, Period III.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay fed,	499.95	33.30	48.20	153.78	252.27	12.40
250 grams dried beet pulp fed,	224.10	7.37	18.19	45.86	151.85	.83
Amount consumed,	724.05	40.67	66.39	199.64	404.12	13.23
260.97 grams manure excreted,	231.82	28.28	31.27	59.83	103.47	8.97
Grams digested,	492.23	12.39	35.12	139.81	300.65	4.26
Minus hay digested,	304.97	9.99	26.03	101.49	163.98	6.70
Dried beet pulp digested,	187.26	2.40	9.09	38.32	136.67	-
Per cent. digested,	76.72	32.56	49.97	83.56	90.00	-

Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	724.05	40.67	66.39	199.64	404.12	13.23
274.86 grams manure excreted,	244.68	29.31	30.27	67.41	108.27	9.42
Grams digested,	479.37	11.36	36.12	132.23	295.85	3.81
Minus hay digested,	304.97	9.99	26.03	101.49	163.98	6.70
Dried beet pulp digested,	174.40	1.37	10.09	30.74	131.87	-
Per cent. digested,	71.45	18.59	55.47	67.03	86.84	-
Average per cent. for both sheep,	74.09	25.58	52.72	75.30	88.42	-

Average nutritive ratio of rations for both sheep, 1:12.4.

2. Series XVII.

Digestion Coefficients of Basal Ration used in this Series.

[English Hay.]

	Periods I.-VII.	Periods VIII.-X.
Dry matter,	62	65
Ash,	34	46
Protein,	55	65
Fiber,	68	67
Nitrogen-free extract,	65	67
Fat,	48	46

Composition of Feedstuffs (Per Cent).

[Dry Matter.]

Period.	Feeds.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.	English hay,	7.75	9.06	31.65	49.16	2.38
II.	English hay,	7.51	9.44	31.73	48.96	2.36
II.	Cocoanut meal,	6.97	21.17	9.23	52.58	10.05
III.	English hay,	8.19	10.36	30.46	48.37	2.62
III.	Cottonseed feed meal, Creamo brand,	5.28	23.75	21.22	44.32	5.43
IV.	English hay,	7.65	10.02	32.48	47.58	2.27
IV.	Wheat screenings,	5.19	17.20	10.52	60.05	7.04
V.	English hay,	6.92	10.17	30.65	49.92	2.34
V.	Molasses dried beet pulp,	5.69	11.44	15.88	66.72	.27
V.	Dried beet pulp,	3.16	8.01	27.22	61.38	.23
VI.	English hay,	6.26	9.50	32.52	49.18	2.54
VI.	Flax shives,	5.59	16.54	35.90	38.75	3.22
VII.	English hay,	7.13	9.85	30.91	49.66	2.45
VII.	Cocoanut meal,	6.06	21.58	9.83	52.42	10.11
VIII.	English hay,	6.73	10.37	30.18	49.84	2.88
IX.	English hay,	5.70	9.90	30.50	51.03	2.87
IX.	Cocoa shells,	8.83	14.55	13.25	58.23	5.14
X.	English hay,	5.46	9.40	31.35	50.77	3.02
X.	Wheat screenings,	4.28	17.50	8.29	64.66	5.27

Composition of Feces (Per Cent).

[Dry Matter.]

Sheep I.

IX.	Cocoa shells,	10.88	15.09	26.20	44.45	3.38

Sheep II.

IX.	Cocoa shells,	10.94	14.13	25.14	46.38	3.41

Sheep III.

V.	Dried beet pulp,	12.31	13.00	20.13	50.50	4.06

Sheep IV.

IV.	Molasses dried beet pulp,	12.17	13.00	27.00	43.82	4.01

Composition of Feces (Per Cent.) — Concluded.

Sheep V.

Period.	Feeds.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.	English hay, ...	13.65	10.80	27.32	45.04	3.19
III.	Cottonseed feed meal, Creamo brand,	12.25	13.11	28.23	43.89	2.52
IV.	Wheat screenings, ...	12.07	10.95	28.21	45.89	2.88
VI.	Flax shives, ...	9.66	9.20	35.55	43.26	2.33
VII.	Cocoanut meal, ...	12.12	11.51	28.81	44.74	2.82
VIII.	English hay, ...	9.87	10.30	28.36	47.35	4.12
X.	Wheat screenings, ...	10.48	11.74	28.47	45.35	3.96

Sheep VI.

Period.	Feeds.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.	English hay, ...	13.50	10.68	26.56	45.88	3.38
II.	Cocoanut meal, ...	13.24	11.93	27.40	44.57	2.86
III.	Cottonseed feed meal, Creamo brand,	11.93	12.50	29.55	43.37	2.65
IV.	Wheat screenings, ...	12.36	10.79	27.77	46.20	2.88
VI.	Flax shives, ...	9.91	9.27	34.88	43.55	2.39
VII.	Cocoanut meal, ...	12.48	11.22	28.80	44.71	2.79
VIII.	English hay, ...	10.88	10.53	27.61	46.21	4.47
X.	Wheat screenings, ...	11.22	11.96	28.54	44.40	3.88

Dry Matter Determinations made at the Time of weighing out the Different Foods, and Dry Matter in Air-dry Feces (Per Cent.).

Sheep I.

Period.	English Hay.	Molasses Dried Beet Pulp.	Dried Beet Pulp.	Cocoa Shells.	Feces.
IX., ...	89.20	–	–	95.47	92.18

Sheep II.

Period.	English Hay.	Molasses Dried Beet Pulp.	Dried Beet Pulp.	Cocoa Shells.	Feces.
IX., ...	89.20	–	–	95.47	92.38

Sheep III.

Period.	English Hay.	Molasses Dried Beet Pulp.	Dried Beet Pulp.	Cocoa Shells.	Feces.
V., ...	92.97	–	90.92	–	94.91

Sheep IV.

Period.	English Hay.	Molasses Dried Beet Pulp.	Dried Beet Pulp.	Cocoa Shells.	Feces.
V., ...	92.97	94.04	–	–	94.85

Dry Matter Determinations made at the Time of weighing out the Different Foods, and Dry Matter in Air-dry Feces (Per Cent.) — Concluded.

Sheep V.

Period.	English Hay.	Cocoanut Meal.	Cotton-seed Feed Meal.	Wheat Screenings.	Flax Shives.	Feces.
I.,	88.50	-	-	-	-	93.30
III.,	87.57	-	89.70	-	-	93.77
IV.,	89.45	-	-	91.94	-	95.41
VI.,	93.25	-	-	-	90.02	95.16
VII.,	90.70	92.86	-	-	-	93.68
VIII.,	90.67	-	-	-	-	92.94
X.,	89.47	-	-	88.52	-	93.11

Sheep VI.

Period.	English Hay.	Cocoanut Meal.	Cotton-seed Feed Meal.	Wheat Screenings.	Flax Shives.	Feces.
I.,	88.50	-	-	-	-	93.25
II.,	87.82	88.37	-	-	-	93.52
III.,	87.57	-	89.70	-	-	94.06
IV.,	89.45	-	-	91.94	-	95.44
VI.,	93.25	-	-	-	90.02	95.18
VII.,	90.70	92.86	-	-	-	93.75
VIII.,	90.67	-	-	-	-	93.03
X.,	89.47	-	-	88.52	-	93.32

Average Daily Amount of Manure excreted and Water drunk (Grams).

Sheep I.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
IX.	Cocoa shells,	898	28.76	2,168

Sheep II.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
IX.	Cocoa shells,	661	28.40	2,510

Sheep III.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
V.	Dried beet pulp,	590	26.33	1,975

Sheep IV.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
V.	Molasses dried beet pulp,	708	24.75	2,482

Average Daily Amount of Manure excreted and Water drunk (Grams) — Concluded.

Sheep V.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
I.	English hay, ...	559	29.30	971
III.	Cottonseed feed meal, Creamo brand, . .	554	29.08	1,493
IV.	Wheat screenings, ...	586	29.55	951
VI.	Flax shives, ...	752	35.84	1,691
VII.	Cocoanut meal, ...	580	27.13	1,839
VIII.	English hay, ...	583	27.93	1,902
X.	Wheat screenings, ...	739	26.85	2,202

Sheep VI.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
I.	English hay, ...	554	28.07	1,474
II.	Cocoanut meal, ...	498	25.50	1,403
III.	Cottonseed feed meal, Creamo brand, . .	570	29.40	2,011
IV.	Wheat screenings, ...	583	28.95	2,165
VI.	Flax shives, ...	685	34.67	2,806
VII.	Cocoanut meal, ...	556	26.31	3,141
VIII.	English hay, ...	536	26.97	3,289
X.	Wheat screenings, ...	662	26.09	3,494

Weights of Animals for Two Days at Beginning and Two Days at the End of Period (Pounds).

Sheep I.

Period.	Character of Food or Ration.	Beginning.		End.	
		First Weight.	Second Weight.	First Weight.	Second Weight.
IX.	Cocoa shells, ...	146.50	144.00	142.50	142.50

Sheep II.

IX.	Cocoa shells, ...	143.50	142.50	143.00	143.00

Sheep III.

V.	Dried beet pulp, ...	160.00	158.75	162.00	160.50

Weights of Animals for Two Days at Beginning and Two Days at the End of Period (Pounds) — Concluded.

Sheep IV.

Period.	Character of Food or Ration.	Beginning.		End.	
		First Weight.	Second Weight.	First Weight.	Second Weight.
V.	Molasses dried beet pulp, ...	164.50	163.00	163.00	162.50

Sheep V.

Period.	Character of Food or Ration.	Beginning.		End.	
		First Weight.	Second Weight.	First Weight.	Second Weight.
I.	English hay, ...	163.25	163.25	159.25	160.75
III.	Cottonseed feed meal, Creamo brand, .	158.25	159.25	158.25	156.50
IV.	Wheat screenings, ...	158.75	158.00	159.50	157.00
VI.	Flax shives, ...	168.50	167.50	164.75	164.75
VII.	Cocoanut meal, ...	167.50	169.75	165.50	163.00
				163.25	166.25
VIII.	English hay, ...	163.50	161.50	162.50	161.50
X.	Wheat screenings, ...	162.00	161.50	158.50	157.50

Sheep VI.

Period.	Character of Food or Ration.	Beginning.		End.	
		First Weight.	Second Weight.	First Weight.	Second Weight.
I.	English hay, ...	146.75	146.75	146.75	147.00
II.	Cocoanut meal, ...	146.75	145.00	143.50	145.50
III.	Cottonseed feed meal, Creamo brand, .	141.50	142.00	141.00	139.25
IV.	Wheat screenings, ...	143.00	142.00	141.25	139.50
VI.	Flax shives, ...	156.50	157.00	154.25	154.50
VII.	Cocoanut meal, ...	151.50	151.50	153.50	152.00
				152.50	150.00
VIII.	English hay, ...	151.00	151.75	152.00	150.50
X.	Wheat screenings, ...	150.00	149.50	148.00	148.25

English Hay, Period I.

Sheep V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed, . . .	708.00	54.87	64.14	224.08	348.06	16.85
293 grams manure excreted, . . .	273.37	37.32	29.52	74.68	123.13	8.72
Grams digested, ...	434.63	17.55	34.62	149.40	224.93	8.13
Per cent. digested, ...	61.39	31.98	53.98	66.67	64.62	48.25

English Hay, Period I — Concluded.

Sheep VI.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed,	708.00	54.87	64.14	224.08	348.06	16.85
280.67 grams manure excreted,	261.72	35.33	27.95	69.51	120.08	8.85
Grams digested,	446.28	19.54	36.19	154.57	227.98	8.00
Per cent. digested,	63.03	35.61	56.42	68.98	65.50	47.48
Average per cent. for both sheep,	62.21	33.80	55.20	67.83	65.06	47.87

Average nutritive ratio of rations for both sheep, 1:11.2.

Cocoanut Meal, Period II.

Sheep VI.

650 grams English hay fed,	570.83	42.87	53.87	181.13	279.49	13.47
150 grams cocoanut meal fed,	132.56	9.24	28.06	12.24	69.70	13.32
Amount consumed,	703.39	52.11	81.93	193.37	349.19	26.79
255 grams manure excreted,	238.48	31.57	28.45	65.34	106.30	6.82
Grams digested,	464.91	20.54	53.48	128.03	242.89	19.97
Minus hay digested,	353.91	14.58	29.63	123.17	181.67	6.47
Cocoanut meal digested,	111.00	5.96	23.85	4.86	61.22	13.50
Per cent. digested,	83.74	64.50	85.00	39.71	87.83	101.35

Average nutritive ratio of ration, 1:7.8.

Cottonseed Feed Meal, Creamo Brand, Period III.

Sheep V.

600 grams English hay fed,	525.42	43.03	54.43	160.04	254.15	13.77
200 grams cottonseed feed meal fed,	179.40	9.47	42.61	38.07	79.51	9.74
Amount consumed,	704.82	52.50	97.04	198.11	333.66	23.51
290.8 grams manure excreted,	272.68	33.40	35.45	76.98	119.68	6.87
Grams digested,	432.14	19.10	61.59	121.13	213.98	16.64
Minus hay digested,	325.76	14.63	29.94	108.83	165.20	6.61
Cottonseed feed meal digested,	106.38	4.47	31.65	12.30	48.78	10.03
Per cent. digested,	59.30	47.20	74.28	32.31	61.35	102.97

Cottonseed Feed Meal, Creamo Brand, Period III — Concluded.

Sheep VI.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	704.82	52.50	97.04	198.11	333.66	23.51
293.99 grams manure excreted,	276.53	32.99	34.57	81.71	119.93	7.33
Grams digested,	428.29	19.51	62.47	116.40	213.73	16.18
Minus hay digested,	325.76	14.63	29.94	108.83	165.20	6.61
Cottonseed feed meal digested,	102.53	4.88	32.53	7.57	48.53	9.57
Per cent. digested,	57.15	51.53	76.34	19.88	61.04	98.25
Average per cent. for both sheep,	58.23	49.37	75.31	26.10	61.20	100.61

Average nutritive ratio of rations for both sheep, 1:5.94.

Wheat Screenings, Period IV.

Sheep V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
600 grams English hay fed,	536.70	41.06	53.78	174.32	255.36	12.18
200 grams wheat screenings fed,	183.88	9.54	31.63	19.34	110.42	12.95
Amount consumed,	720.58	50.60	85.41	193.66	365.78	25.13
295.54 grams manure excreted,	281.97	34.03	30.88	79.54	129.40	8.12
Grams digested,	438.61	16.57	54.53	114.12	236.38	17.01
Minus hay digested,	332.75	13.96	29.58	118.54	165.98	5.85
Wheat screenings digested,	105.86	2.61	24.95	-	70.40	11.16
Per cent. digested,	57.57	27.36	78.88	-	63.76	86.18

Sheep VI.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	720.58	50.60	85.41	193.66	365.78	25.13
289.51 grams manure excreted,	276.31	34.15	29.81	76.73	127.66	7.96
Grams digested,	444.27	16.45	55.60	116.93	238.12	17.17
Minus hay digested,	332.75	13.96	29.58	118.54	165.98	5.85
Wheat screenings digested,	111.52	2.49	26.02	-	72.14	11.32
Per cent. digested,	60.65	26.19	82.97	-	65.33	87.41
Average per cent. for both sheep,	59.11	26.73	80.93	-	64.55	86.80

Average nutritive ratio of rations for both sheep, 1:7.1.

Dried Beet Pulp, Period V.

Sheep III.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay fed,	511.34	35.39	52.00	156.73	255.25	11.97
250 grams dried beet pulp fed,	227.30	7.18	18.21	61.87	139.52	.52
Amount consumed,	738.64	42.57	70.21	218.60	394.77	12.49
263.27 grams manure excreted,	249.87	30.76	32.48	50.30	126.19	10.14
Grams digested,	488.77	11.81	37.73	168.30	268.58	2.35
Minus hay digested,	317.03	12.03	28.60	106.58	165.91	5.75
Dried beet pulp digested,	171.74	–	9.13	61.72	102.67	–
Per cent. digested,	75.56	–	50.14	99.76	73.59	–

Average nutritive ratio of ration, 1:11.7.

Molasses Dried Beet Pulp, Period V.

Sheep IV.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay fed,	511.34	35.39	52.00	156.73	255.25	11.97
250 grams molasses dried beet pulp fed,	235.10	13.38	26.90	37.33	156.86	.63
Amount consumed,	746.44	48.77	78.90	194.06	412.11	12.60
247.50 grams manure excreted,	234.75	28.57	30.52	63.38	102.87	9.41
Grams digested,	511.69	20.20	48.38	130.68	309.24	3.19
Minus hay digested,	317.03	12.03	28.60	106.58	165.91	5.75
Molasses dried beet pulp digested,	194.66	8.17	19.78	24.10	143.33	–
Per cent. digested,	82.80	61.06	73.53	64.56	91.37	–

Average nutritive ratio of ration, 1:9.2.

Flax Shives, Period VI.

Sheep V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
600 grams English hay fed,	559.50	35.02	53.15	181.95	275.17	14.21
250 grams flax shives fed,	225.05	12.58	37.22	80.79	87.21	7.25
Amount consumed,	784.55	47.60	90.37	262.74	362.38	21.46
358.38 grams manure excreted,	341.03	32.94	31.37	121.24	147.53	7.95
Grams digested,	443.52	14.66	59.00	141.50	214.85	13.51
Minus hay digested,	346.89	11.91	29.23	123.73	178.86	6.82
Flax shives digested,	96.63	2.75	29.77	17.77	35.99	6.69
Per cent. digested,	42.94	21.86	79.98	22.00	41.27	92.26

Flax Shives, Period VI — Concluded.

Sheep VI.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above, . .	784.55	47.60	90.37	262.74	362.38	21.46
346.74 grams manure excreted, . .	330.03	32.71	30.59	115.11	143.73	7.89
Grams digested, ...	454.52	14.89	59.78	147.63	218.65	13.57
Minus hay digested, ...	346.89	11.91	29.23	123.73	178.86	6.82
Flax shives digested, ...	107.63	2.98	30.55	23.90	39.79	6.75
Per cent. digested, ...	47.82	23.69	82.08	29.58	45.63	93.09
Average per cent. for both sheep, .	45.38	22.78	81.03	25.79	43.45	92.68

Average nutritive ratio of rations for both sheep, 1:6.6.

Cocoanut Meal, Period VII.

Sheep V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
650 grams English hay fed, . .	589.55	42.03	58.07	182.23	292.78	14.44
150 grams cocoanut meal fed, . .	139.29	8.44	30.06	13.69	73.02	14.08
Amount consumed, ...	728.84	50.47	88.13	195.92	365.80	28.52
271.34 grams manure excreted, . .	254.19	30.81	29.26	73.23	113.72	7.17
Grams digested, ...	474.65	19.66	58.87	122.69	252.08	21.35
Minus hay digested, ...	365.52	14.29	31.94	123.92	190.31	6.93
Cocoanut meal digested, . . .	109.13	5.37	26.93	-	61.77	14.42
Per cent. digested, ...	78.34	63.63	89.59	-	84.59	102.41

Sheep VI.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above, . .	728.84	50.47	88.13	195.92	365.80	28.52
263.11 grams manure excreted, . .	246.67	30.78	27.68	71.04	110.29	6.88
Grams digested, ...	482.17	19.69	60.45	124.88	255.51	21.64
Minus hay digested, ...	365.52	14.29	31.94	123.92	190.31	6.93
Cocoanut meal digested, . . .	116.65	5.40	28.51	.96	65.20	14.71
Per cent. digested, ...	83.74	63.98	94.84	7.01	89.29	104.47
Average per cent. for both sheep, .	81.04	63.81	92.22	-	86.94	103.44

Average nutritive ratio of rations for both sheep, 1:7.1.

English Hay, Period VIII.

Sheep V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed, . .	725.36	48.82	75.22	218.91	361.52	20.89
279.28 grams manure excreted, . .	259.56	25.62	26.73	73.61	122.91	10.69
Grams digested, ...	465.80	23.20	48.49	145.30	238.61	10.20
Per cent. digested, ...	64.22	47.52	64.46	66.37	66.00	48.83

Sheep VI.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed, . .	725.36	48.82	75.22	218.91	361.52	20.89
269.70 grams manure excreted, . .	250.90	27.30	26.42	69.27	115.94	11.97
Grams digested, ...	474.46	21.52	48.80	149.64	245.58	8.92
Per cent. digested, ...	65.41	44.08	64.88	68.36	67.93	42.70
Average per cent. for both sheep, .	64.82	45.80	64.67	67.37	66.97	45.77

Average nutritive ratio of rations for both sheep, 1:8.4.

Cocoa Shells, Period IX.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
650 grams English hay fed, . .	579.80	33.05	57.40	176.83	295.88	16.64
150 grams cocoa shells fed, . . .	143.21	12.65	20.84	18.98	83.38	7.36
Amount consumed, ...	723.01	45.70	78.24	195.81	379.26	24.00
287.64 grams manure excreted, . .	265.15	28.85	40.01	69.47	117.86	8.96
Grams digested, ...	457.86	16.85	38.23	126.34	261.40	15.04
Minus hay digested, ...	376.87	15.20	37.31	118.48	198.24	7.65
Cocoa shells digested, ...	80.99	1.65	.92	7.86	63.16	7.39
Per cent. digested, ...	56.55	13.04	4.41	41.41	75.75	100.41

Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above, . .	723.01	45.70	78.24	195.81	379.26	24.00
284.01 grams manure excreted, . .	262.37	28.70	37.07	65.96	121.69	8.95
Grams digested, ...	460.64	17.00	41.17	129.85	257.57	15.05
Minus hay digested, ...	376.87	15.20	37.31	118.48	198.24	7.65
Cocoa shells digested, ...	83.77	1.80	3.86	11.37	59.33	7.40
Per cent. digested, ...	58.49	14.23	18.52	59.91	71.16	100.54
Average per cent. for both sheep, .	57.52	13.64	11.47	50.66	73.46	100.48

Average nutritive ratio of rations for both sheep, 1:10.6.

Wheat Screenings, Period X.

Sheep V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
600 grams English hay fed,	536.82	29.31	50.46	168.29	272.55	16.21
200 grams wheat screenings fed,	177.04	7.58	30.98	14.68	114.47	9.33
Amount consumed,	713.86	36.89	81.44	182.97	387.02	25.54
268.48 grams manure excreted,	249.98	26.20	29.35	71.17	113.36	9.90
Grams digested,	463.88	10.69	52.09	111.80	273.66	15.64
Minus hay digested,	348.93	13.48	32.80	112.75	182.61	7.46
Wheat screenings digested,	114.95	-	19.29	-	91.05	8.18
Per cent. digested,	64.93	-	62.26	-	79.54	87.67

Sheep VI.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	713.86	36.89	81.44	182.97	387.02	25.54
260.94 grams manure excreted,	243.51	27.32	29.12	69.50	108.12	9.45
Grams digested,	470.35	9.57	52.32	113.47	278.90	16.09
Minus hay digested,	348.93	13.48	32.80	112.75	182.61	7.46
Wheat screenings digested,	121.42	-	19.52	-	96.29	8.63
Per cent. digested,	68.58	-	63.01	-	84.12	92.50
Average per cent. for both sheep,	66.76	-	62.64	-	81.83	90.09

Average nutritive ratio of rations for both sheep, 1:8.1.

3. Series XVIII.

Digestion Coefficients of Basal Ration used in this Series.

	English Hay. Sheep I. and II.	English Hay. Sheep V. and VI.	English Hay and Corn Meal. Periods X. and XII. Sheep I. and II.
Dry matter,	65	65	70
Ash,	31	46	43
Protein,	61	65	63
Fiber,	70	67	71
Nitrogen-free extract,	67	67	74
Fat,	53	46	59

Composition of Feedstuffs (Per Cent).

[Dry Matter.]

Period.	Feedstuffs.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.	English hay,	4.90	9.75	31.46	50.95	2.94
II.	English hay,	5.78	9.56	31.48	50.45	2.73
II.	Corn meal,	1.39	10.74	2.77	80.07	5.03
VIII.	Brook Farm hay,	6.46	8.27	33.89	49.31	2.07
VIII.	Waste Sheep I.,	4.68	4.56	38.09	51.61	1.06
VIII.	Waste Sheep II.,	6.09	7.28	33.46	51.48	1.69
IX.	English hay,	6.53	9.35	32.10	49.13	2.89
IX.	CXX Feed, Postum Cereal refuse.	2.74	19.57	18.11	56.46	3.12
X.	English hay,	6.41	9.80	31.84	49.31	2.64
X.	Corn meal,	1.46	10.93	2.60	80.15	4.86
X.	Gloucester fish meal,	24.01	73.17	-	-	2.82
XI.	English hay,	6.72	9.72	31.65	49.32	2.59
XI.	Molassine meal,	9.40	10.81	7.54	71.72	.53
XII.	English hay,	6.49	9.62	31.64	49.51	2.74
XII.	Corn meal,	1.50	10.78	2.72	80.15	4.85
XII.	Wilcox fish guano,	16.90	55.46	-	-	7.72
XIII.	English hay,	6.40	8.80	32.45	49.53	2.82
XIII.	Mellen's Food refuse,	4.38	13.51	18.24	59.64	4.23
XIV.	English hay,	6.47	8.90	31.89	49.95	2.79
XIV.	Molassine meal,	9.47	12.49	7.79	69.65	.60
XIV.	Waste Sheep I.,	13.60	11.33	16.54	57.08	1.45
XIV.	Brook Farm hay,	6.32	8.90	32.12	50.53	2.13

Composition of Feces (Per Cent).

[Dry Matter.]

Sheep I.

Period.	Feeds.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.	English hay,	9.73	11.37	26.53	48.35	4.02
II.	Corn meal,	9.33	12.47	25.89	48.16	4.15
VIII.	Brook Farm hay,	9.04	11.62	26.31	49.73	3.30
X.	Gloucester fish meal,	15.30	17.46	21.67	42.17	3.40
XII.	Wilcox fish guano,	14.34	14.74	23.29	44.29	3.34
XIV.	Molassine meal,	11.48	13.22	24.80	47.32	3.18

Composition of Feces (Per Cent.) — Concluded.

[Dry Matter.]

Sheep II.

Period.	Feeds.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.	English hay, ...	9.83	10.60	27.48	48.08	4.01
II.	Corn meal, ...	10.12	11.68	26.73	47.08	4.39
VIII.	Brook Farm hay, . . .	8.57	9.87	28.59	49.88	3.09
X.	Gloucester fish meal, . . .	16.92	18.35	20.29	40.71	3.73
XII.	Wilcox fish guano, . . .	15.36	16.41	21.36	43.30	3.57

Sheep V.

Period.	Feeds.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
IX.	CXX Feed, Postum Cereal refuse.	8.38	17.47	28.78	42.22	3.15
XI.	Molassine meal, ...	8.76	12.64	26.74	48.06	3.80
XIII.	Mellen's Food refuse, . . .	10.32	10.99	27.60	47.81	3.28
XIV.	Brook Farm hay, . . .	9.64	10.21	30.07	47.02	3.06

Sheep VI.

Period.	Feeds.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
IX.	CXX Feed, Postum Cereal refuse.	8.36	16.76	29.35	42.54	2.99
XI.	Molassine meal, ...	9.03	12.54	26.70	48.13	3.60
XIII.	Mellen's Food refuse, . . .	10.54	11.69	25.81	48.84	3.12

Dry Matter Determinations made at the Time of weighing out the Different Foods, and Dry Matter in Air-dry Feces (Per Cent.).

Sheep I.

Period.	English Hay.	Corn Meal.	Brook Farm Hay.	Gloucester Fish Meal.	Wilcox Fish Guano.	Molassine Meal.	CXX Feed.	Mellen's Food Refuse.	Waste.	Feces.
I.	88.62	-	-	-	-	-	-	-	-	92.50
II.	88.32	86.55	-	-	-	-	-	-	-	93.02
VIII.	-	-	88.97	-	-	-	-	-	90.12	95.52
X.	90.75	88.36	-	94.28	-	-	-	-	-	93.52
XII.	89.25	87.57	-	-	91.62	-	-	-	-	93.09
XIV.	89.60	-	-	-	-	80.81	-	-	74.76	92.20

Dry Matter Determinations made at the Time of weighing out the Different Foods, and Dry Matter in Air-dry Feces (Per Cent.) — Concluded.

Sheep II.

Period.	English Hay.	Corn Meal.	Brook Farm Hay.	Gloucester Fish Meal.	Wilcox Fish Guano.	Molassine Meal.	CXX Feed.	Mellen's Food Refuse.	Waste.	Feces.
I.	88.62	–	–	–	–	–	–	–	–	92.75
II.	88.32	86.55	–	–	–	–	–	–	–	93.31
VIII.	–	–	88.97	–	–	–	–	–	90.12	95.45
X.	90.75	88.36	–	94.28	–	–	–	–	–	93.32
XII.	89.25	87.57	–	–	91.62	–	–	–	–	93.18

Sheep V.

Period.	English Hay.	Corn Meal.	Brook Farm Hay.	Gloucester Fish Meal.	Wilcox Fish Guano.	Molassine Meal.	CXX Feed.	Mellen's Food Refuse.	Waste.	Feces.
IX.	90.07	–	–	–	–	–	90.82	–	–	93.63
XI.	89.82	–	–	–	–	81.94	–	–	–	94.08
XIII.	90 00	–	–	–	–	–	–	93.02	–	94.18
XIV.	–	–	89.85	–	–	–	–	–	–	92.93

Sheep VI.

Period.	English Hay.	Corn Meal.	Brook Farm Hay.	Gloucester Fish Meal.	Wilcox Fish Guano.	Molassine Meal.	CXX Feed.	Mellen's Food Refuse.	Waste.	Feces.
IX.	90.07	–	–	–	–	–	90.82	–	–	93.71
XI.	89.82	–	–	–	–	81.94	–	–	–	94.04
XIII.	90.00	–	–	–	–	–	–	93.02	–	93.99

Average Daily Amount of Manure excreted and Water drunk (Grams).

Sheep I.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
I.	English hay,	648	25.83	2,586
II.	Corn meal,	426	21.02	1,660
VIII.	Brook Farm hay,	781	25.46	2,235
X.	Gloucester fish meal,	658	27.16	3,860
XII.	Wilcox fish guano,	538	24.41	2,965
XIV.	Molassine meal,	712	26.55	2,926

Sheep II.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
I.	English hay,	584	27.05	2,413
II.	Corn meal,	497	22.79	2,126
VIII.	Brook Farm hay,	789	27.96	2,668
X.	Gloucester fish meal,	537	24.33	3,596
XII.	Wilcox fish guano,	694	25.02	3,248

Average Daily Amount of Manure excreted and Water drunk (Grams) — Concluded.

Sheep V.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
IX.	CXX Feed, Postum Cereal refuse,	827	31.68	1,696
XI.	Molassine meal,	549	24.20	1,848
XIII.	Mellen's Food refuse,	778	29.72	2,238
XIV.	Brook Farm hay,	752	30.95	3,051

Sheep VI.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
IX.	CXX Feed, Postum Cereal refuse,	772	33.02	2,915
XI.	Molassine meal,	684	26.88	3,351
XIII.	Mellen's Food refuse,	946	31.26	3,801

Weights of Animals for Two Days at Beginning and Two Days at the End of Period (Pounds).

Sheep I.

Period.	Character of Food or Ration.	Beginning.		End.	
		First Weight.	Second Weight.	First Weight.	Second Weight.
I.	English hay,	143.00	143.00	145.50	144.75
II.	Corn meal,	140.00	139.50	140.75	141.00
VIII.	Brook Farm hay,	134.50	135.00	136.25	136.00
X.	Gloucester fish meal,	131.50	134.50	136.00	136.00
XII.	Wilcox fish guano,	138.75	138.25	140.25	140.25
XIV.	Molassine meal,	136.00	135.00	135.75	135.25

Sheep II.

Period.	Character of Food or Ration.	Beginning.		End.	
		First Weight.	Second Weight.	First Weight.	Second Weight.
I.	English hay,	142.50	142.50	141.50	141.50
II.	Corn meal,	137.75	137.50	136.00	136.00
VIII.	Brook Farm hay,	135.75	136.00	135.25	135.00
X.	Gloucester fish meal,	135.25	135.75	137.00	137.50
XII.	Wilcox fish guano,	139.00	139.00	138.25	139.00

Weights of Animals for Two Days at Beginning and Two Days at the End of Period (Pounds) — Concluded.

Sheep V.

Period.	Character of Food or Ration.	Beginning.		End.	
		First Weight.	Second Weight.	First Weight.	Second Weight.
IX.	CXX Feed, Postum Cereal refuse, . .	166.25	166.50	163.00	163.00
XI.	Molassine meal, ...	160.25	160.25	157.50	157.75
XIII.	Mellen's Food refuse, ...	168.50	168.50	158.50	158.75
XIV.	Brook Farm hay, ...	156.75	156.00	160.75	157.75

Sheep VI.

IX.	CXX feed, Postum Cereal refuse, . .	158.25	159.25	157.25	156.25
XI.	Molassine meal, ...	154.00	154.00	155.75	154.75
XIII.	Mellen's Food refuse, ...	155.00	155.00	154.75	153.75

English Hay, Period I.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed, . . .	708.96	34.74	69.12	223.04	361.22	20.84
258.27 grams manure excreted, . .	238.90	23.24	27.16	63.38	115.52	9.60
Grams digested, ...	470.06	11.50	41.96	159.66	245.70	11.24
Per cent. digested, ...	66.30	33.10	60.42	71.58	68.02	53.93

Sheep II.

800 grams English hay fed, . . .	708.96	34.74	69.12	223.04	361.22	20.84
270.48 grams manure excreted, . .	250.87	24.66	26.59	68.94	120.62	10.06
Grams digested, ...	458.09	10.08	42.53	154.10	240.60	10.78
Per cent. digested, ...	64.61	29.02	61.53	69.09	66.61	51.73
Average per cent. for both sheep, .	65.46	31.06	60.98	70.34	67.32	52.83

Average nutritive ratio of rations for both sheep, 1:10.0.

English Hay, Corn Meal, Period II.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
650 grams English hay fed,	574.08	33.18	54.88	180.72	289.63	15.67
125 grams corn meal fed,	108.19	1.50	11.62	3.00	86.63	5.44
Amount consumed,	682.27	34.68	66.50	183.72	376.26	21.11
210.20 grams manure excreted,	195.53	18.24	24.38	50.62	94.18	8.11
Grams digested,	486.74	16.44	42.12	133.10	282.08	13.00
Per cent. digested,	71.34	47.40	63.34	72.45	74.97	61.58

Sheep II.

Amount consumed as above,	682.27	34.68	66.50	183.72	376.26	21.11
227.87 grams manure excreted,	212.63	21.52	24.84	56.83	100.11	9.33
Grams digested,	469.64	13.16	41.66	126.89	276.15	11.78
Per cent. digested,	68.83	37.95	62.65	69.07	73.39	55.80
Average per cent. for both sheep,	70.09	42.68	63.00	70.76	74.18	58.69

Average nutritive ratio of rations for both sheep, 1:11.6.

Brook Farm Hay, Period VIII.

Sheep I.

800 grams Brook Farm hay fed,	711.76	45.98	58.86	241.22	350.97	14.73
87.43 grams waste,	78.79	3.69	3.59	30.01	40.66	.84
Amount consumed,	632.97	42.29	55.27	211.21	310.31	13.89
254.57 grams manure excreted,	242.40	21.91	28.17	63.78	120.54	8.00
Brook Farm hay digested,	390.57	20.38	27.10	147.43	189.77	5.89
Per cent. digested,	61.70	48.19	49.03	69.80	61.15	42.40

Sheep II.

800 grams Brook Farm hay fed,	711.76	45.98	58.86	241.22	350.97	14.73
77.14 grams waste,	69.55	4.24	5.06	23.27	35.80	1.18
Amount consumed,	642.21	41.74	53.80	217.95	315.17	13.55
279.58 grams manure excreted,	266.86	22.87	26.34	76.30	133.10	8.25
Brook Farm hay digested,	375.35	18.87	27.46	141.65	182.07	5.30
Per cent. digested,	58.45	45.21	51.04	64.99	57.77	39.11
Average per cent. for both sheep,	60.08	46.70	50.04	67.40	59.96	40.76

Average nutritive ratio of rations for both sheep, 1:12.5.

CXX Feed, Postum Cereal Refuse, Period IX.

Sheep V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay fed,	495.39	32.35	46.32	159.02	243.38	14.32
250 grams CXX Feed fed,	227.05	6.22	44.43	41.12	128.20	7.08
Amount consumed,	722.44	38.57	90.75	200.14	371.58	21.40
316.80 grams manure excreted,	296.62	24.86	51.82	85.37	125.23	9.34
Grams digested,	425.82	13.71	38.93	114.77	246.35	12.06
Minus hay digested,	322.00	14.88	30.11	106.54	163.06	6.59
CXX Feed digested,	103.82	–	8.82	8.23	83.29	5.47
Per cent. digested,	45.73	–	19.85	20.01	64.97	77.26

Sheep VI.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	722.44	38.57	90.75	200.14	371.58	21.40
330.20 grams manure excreted,	309.43	25.87	51.86	90.82	131.63	9.25
Grams digested,	413.01	12.70	38.89	109.32	239.95	12.15
Minus hay digested,	322.00	14.88	30.11	106.54	163.06	6.59
CXX Feed digested,	91.01	–	8.78	2.78	76.89	5.56
Per cent. digested,	40.08	–	19.76	6.76	59.98	78.53
Average per cent. for both sheep,	42.91	–	19.81	13.39	62.48	77.90

Average nutritive ratio of rations for both sheep, 1:9.8.

Gloucester Fish Meal, Period X.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
650 grams English hay fed,	589.88	37.81	57.81	187.82	290.87	15.57
125 grams corn meal fed,	110.45	1.61	12.07	2.87	88.53	5.37
100 grams Gloucester fish meal fed,	94.28	22.64	68.98	–	–	2.66
Amount consumed,	794.61	62.06	138.86	190.69	379.40	23.60
271.60 grams manure excreted,	254.00	38.86	44.35	55.04	107.11	8.64
Grams digested,	540.61	23.20	94.51	135.65	272.29	14.96
Minus hay and corn meal digested,	490.23	16.95	44.02	135.39	280.76	12.35
Gloucester fish meal digested,	50.38	6.25	50.49	.26	–	2.61
Per cent. digested,	53.44	27.61	73.20	–	–	98.12

Gloucester Fish Meal, Period X — Concluded.

Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	794.61	62.06	138.86	190.69	379.40	23.60
243.33 grams manure excreted,	227.08	38.42	41.67	46.07	92.45	8.47
Grams digested,	567.53	23.64	97.19	144.62	286.95	15.13
Minus hay and corn meal digested,	490.23	16.95	44.02	135.39	280.76	12.35
Gloucester fish meal digested,	77.30	6.69	53.17	9.23	6.19	2.78
Per cent. digested,	81.99	29.55	77.08	-	-	104.51
Average per cent. for both sheep,	67.72	28.58	75.14	-	-	101.32

Average nutritive ratio of rations for both sheep, 1:5.2.

Molassine Meal, Period XI.

Sheep V.

550 grams English hay fed,	494.01	33.20	48.02	156.35	243.65	12.79
200 grams Molassine meal fed,	163.88	15.40	17.72	12.36	117.53	.87
Amount consumed,	657.89	48.60	65.74	168.71	361.18	13.66
241.96 grams manure excreted,	227.64	19.94	28.77	60.87	109.41	8.65
Grams digested,	430.25	28.66	36.97	107.84	251.77	5.01
Minus hay digested,	321.11	15.27	31.21	104.75	163.25	5.88
Molassine meal digested,	109.14	13.39	5.76	3.09	88.52	-
Per cent. digested,	66.60	86.95	32.51	25.00	75.32	-

Sheep VI.

600 grams English hay fed,	538.92	36.22	52.38	170.57	265.79	13.96
200 grams Molassine meal fed,	163.88	15.40	17.72	12.36	117.53	.87
Amount consumed,	702.80	51.62	70.10	182.93	383.32	14.83
268.78 grams manure excreted,	252.76	22.82	31.70	67.49	121.65	9.10
Grams digested,	450.04	28.80	38.40	115.44	261.67	5.73
Minus hay digested,	350.30	16.66	34.05	142.82	178.08	6.42
Molassine meal digested,	99.74	12.14	4.35	-	83.59	-
Per cent. digested,	60.86	78.83	24.55	-	71.12	-
Average per cent. for both sheep,	63.73	82.89	28.53	-	73.22	-

Average nutritive ratio of rations for both sheep, 1:9.4.

Wilcox Fish Guano, Period XII.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
650 grams English hay fed, . .	580.13	37.65	55.81	183.55	287.22	15.90
125 grams corn meal fed, . . .	109.46	1.64	11.80	2.98	87.73	5.31
100 grams Wilcox fish guano fed, .	91.62	17.36	57.42	–	–	9.30
Amount consumed, ...	781.21	56.65	125.03	186.53	374.95	30.51
244.11 grams manure excreted, . .	227.24	32.59	33.50	52.92	100.64	7.59
Grams digested, ...	553.97	24.06	91.53	133.61	274.31	22.92
Minus hay and corn meal digested, .	482.71	16.89	42.59	132.44	277.46	12.51
Fish guano digested, ...	71.26	7.17	48.94	1.17	–	10.41
Per cent. digested, ...	77.78	41.30	85.23	–	–	111.96

Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above, . .	781.21	56.65	125.03	186.53	374.95	30.51
250.16 grams manure excreted, . .	233.10	35.80	38.25	49.79	100.94	8.32
Grams digested, ...	548.11	20.85	86.78	136.74	274.01	22.19
Minus hay and corn meal digested, .	482.71	16.89	42.59	132.44	277.46	12.51
Fish guano digested, ...	65.40	3.96	44.19	4.30	–	9.68
Per cent. digested, ...	71.38	22.81	76.96	–	–	104.09
Average per cent. for both sheep, .	74.58	32.06	81.10	–	–	108.03

Average nutritive ratio of rations for both sheep, 1:5.15.

Mellen's Food Refuse, Period XIII.

Sheep V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay fed, . .	495.00	31.68	43.56	160.63	245.17	13.96
250 grams Mellen's Food refuse fed, .	232.55	10.19	31.42	42.42	138.68	9.84
Amount consumed, ...	727.55	41.87	74.98	203.05	383.85	23.80
297.21 grams manure excreted, . .	279.91	28.89	30.76	77.26	133.82	9.18
Grams digested, ...	447.64	12.98	44.22	125.89	250.03	14.62
Minus hay digested, ...	321.75	14.57	28.31	107.62	164.26	6.42
Grams Mellen's Food refuse digested, .	125.89	–	15.91	18.17	85.77	8.20
Per cent. digested, ...	54.13	–	50.64	42.83	61.85	83.33

Mellen's Food Refuse, Period XIII — Concluded.

Sheep VI.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	727.55	41.87	74.98	203.05	383.85	23.80
312.56 grams manure excreted,	293.78	30.96	34.34	75.82	143.49	9.17
Grams digested,	433.77	10.91	40.64	127.23	240.36	14.63
Minus hay digested,	321.75	14.57	28.31	107.62	164.26	6.42
Grams Mellen's Food refuse digested,	112.02	-	12.33	19.61	76.10	8.21
Per cent. digested,	48.17	-	39.24	46.23	54.87	83.43
Average per cent. for both sheep,	51.15	-	44.94	44.53	58.36	83.38

Average nutritive ratio of rations for both sheep, 1:9.52.

Molassine Meal, Period XIV.

Sheep I.

600 grams English hay fed,	537.60	34.78	47.85	171.44	268.53	15.00
200 grams Molassine meal fed,	161.62	15.31	20.19	12.59	112.56	.97
Amount fed,	699.22	50.09	68.04	184.03	381.09	15.97
11.95 grams waste,	8.93	1.21	1.01	1.48	5.10	.13
Amount consumed,	690.29	48.88	67.03	182.55	375.99	15.84
265.45 grams manure excreted,	244.74	28.10	32.35	60.70	115.81	7.78
Grams digested,	445.55	20.78	34.68	121.85	260.18	8.06
Minus hay digested,	349.44	10.78	29.19	120.01	179.92	7.95
Molassine meal digested,	96.11	10.00	5.49	1.84	80.26	.11
Per cent. digested,	59.47	65.31	27.19	14.61	71.30	11.34

Average nutritive ratio of ration, 1:11.5.

Brook Farm Hay, Period XIV.

Sheep V.

750 grams Brook Farm hay fed,	669.38	42.30	59.57	215.00	318.25	14.26
309.50 grams manure excreted,	287.62	27.73	29.37	86.49	135.23	8.80
Grams digested,	381.76	14.57	30.20	128.51	183.02	5.46
Per cent. digested,	57.03	34.44	50.70	59.77	57.51	38.29

Average nutritive ratio of ration, 1:10.7.

4. Series XIX.

Digestion Coefficients of Basal Ration used in this Series.

	English Hay.	English Hay and Gluten Feed.
Dry matter,	65	66
Ash,	46	31
Protein,	65	68
Fiber,	67	66
Nitrogen-free extract,	67	70
Fat,	46	56

Composition of Feedstuffs (Per Cent.).

[Dry Matter.]

Period.	Feeds.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.	English hay,	6.19	10.01	30.58	50.63	2.59
I.	Gluten feed,	1.10	27.75	8.78	58.00	4.37
I.	Molassine meal,	8.63	11.29	11.09	68.26	.73
II.	English hay,	5.83	9.52	31.40	50.98	2.27
II.	Gluten feed,	1.05	27.84	8.75	57.78	4.58

Composition of Feces (Per Cent.).

[Dry Matter.]

Sheep V.

Period.	Feeds.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.	Molassine meal,	8.82	12.68	28.90	46.58	3.02
II.	English hay and gluten feed,	9.25	12.79	27.62	46.75	3.59

Sheep VI.

Period.	Feeds.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.	Molassine meal,	8.65	12.57	27.34	48.27	3.17
II.	English hay and gluten feed,	10.47	12.62	26.49	46.81	3.61

Dry Matter Determinations made at the Time of weighing out the Different Foods, and Dry Matter in Air-dry Feces (Per Cent.).

Sheep V.

Period.	English Hay.	Gluten Feed.	Molassine Meal.	Feces.
I.,	86.45	89.78	83.41	90.92
II.,	88.02	89.55	-	92.47

Sheep VI.

Period.	English Hay.	Gluten Feed.	Molassine Meal.	Feces.
I.,	86.45	89.78	83.41	90.88
II.,	88.02	89.55	-	92.59

Average Daily Amount of Manure excreted and Water drunk (Grams).

Sheep V.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
I.	Molassine meal,	676	30.43	2,771
II.	English hay and gluten feed,	470	22.65	2,589

Sheep VI.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
I.	Molassine meal,	627	29.35	1,899
II.	English hay and gluten feed,	465	22.30	1,183

Weights of Animals for Two Days at Beginning and Two Days at End of Period (Pounds).

Sheep V.

Period.	Character of Food or Ration.	Beginning.		End.	
		First Weight.	Second Weight.	First Weight.	Second Weight.
I.	Molassine meal,	133.25	131.75	131.50	132.25
II.	English hay and gluten feed,	132.75	131.50	129.75	130.00

Sheep VI.

Period.	Character of Food or Ration.	Beginning.		End.	
		First Weight.	Second Weight.	First Weight.	Second Weight.
I.	Molassine meal,	156.75	157.50	159.50	-
II.	English hay and gluten feed,	157.25	158.50	155.25	152.75

Molassine Meal, Period I.

Sheep V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay fed,	475.48	29.43	47.60	145.40	240.74	12.31
150 grams gluten feed fed,	134.67	1.48	37.37	11.82	78.11	5.89
200 grams Molassine meal fed,	166.82	14.40	18.83	18.50	113.87	1.22
Amount consumed,	776.97	45.31	103.80	175.72	432.72	19.42
304.25 grams manure excreted,	276.62	24.40	35.08	79.94	128.85	8.35
Grams digested,	500.35	20.91	68.72	95.78	303.87	11.07
Minus English hay and gluten feed digested.	402.70	9.58	57.78	103.77	223.20	10.19
Molassine meal digested,	97.65	11.33	10.94	–	80.67	.88
Per cent. digested,	58.54	78.47	58.10	–	70.84	72.13

Sheep VI.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	776.97	45.31	103.80	175.72	432.72	19.42
293.54 grams manure excreted,	266.77	23.08	33.53	72.93	128.77	8.46
Grams digested,	510.20	22.23	70.27	102.79	303.95	10.96
Minus English hay and gluten feed digested.	402.70	9.58	57.78	103.77	223.20	10.19
Molassine meal digested,	107.50	12.65	12.49	–	80.75	.77
Per cent. digested,	64.44	87.85	66.33	–	70.91	63.11
Average per cent. for both sheep,	61.49	83.16	62.22	–	70.88	67.62

Average nutritive ratio of rations for both sheep, 1:6.15.

English Hay, Gluten Feed, Period II.

Sheep V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay fed,	484.11	28.22	46.09	152.01	246.80	10.99
150 grams gluten feed fed,	134.33	1.41	37.40	11.75	77.62	6.15
Amount consumed,	618.44	29.63	83.49	163.76	324.42	17.14
226.53 grams manure excreted,	209.47	19.38	26.79	57.86	97.92	7.52
Grams digested,	408.97	10.25	56.70	105.90	226.50	9.62
Per cent. digested,	66.13	34.59	67.91	64.67	69.82	56.13

Sheep VI.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	618.44	29.63	83.49	163.76	324.42	17.14
223.00 grams manure excreted,	206.48	21.62	26.06	54.70	96.65	7.45
Grams digested,	411.96	8.01	57.43	109.06	227.77	9.69
Per cent. digested,	66.61	27.03	68.79	66.60	70.21	56.53
Average per cent. for both sheep,	66.37	30.81	68.35	65.64	70.02	56.33

Average nutritive ratio of rations for both sheep, 1:6.23.

5. Discussion of Results.

Owing to the fact that a number of the tests were repeated in a series following, the coefficients secured for each feed in the several series are brought together and discussed below.

English Hay.

But two different lots of hay were used in all of these experiments. It consisted of mixed grasses with June grass (*Poa pratensis*) predominating; cut while in blossom, well cured and in good condition. Before feeding it was cut fine by running it through a feed cutter, and thoroughly mixed to insure uniformity through the entire lot.

Summary of Coefficients, English Hay, Series XVI., Period I.; Series XVII., Periods I. and VIII.; Series XVIII., Period I.

Lot.	Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.	I.,	1	1	62.92	32.24	54.53	69.00	65.85	54.06
	II.,	1	1	59.36	27.27	52.79	62.91	63.51	54.68
	V.,	1	1	61.39	31.98	53.98	66.67	64.62	48.25
	VI.,	1	1	63.03	35.61	56.42	68.98	65.50	47.48
	Average,	1	4	61.68	31.78	54.43	66.89	64.87	51.12
II.	I.,	1	1	66.30	33.10	60.42	71.58	68.02	53.93
	II.,	1	1	64.61	29.02	61.53	69.09	66.61	51.73
	V.,	1	1	64.22	47.52	64.46	66.37	66.00	48.83
	VI.,	1	1	65.41	44.08	64.88	68.36	67.93	42.70
	Average,	1	4	65.14	38.43	62.82	68.85	67.14	49.30
	Average of all trials of similar hay for comparison.	21	73	61.00	47.00	57.00	62.00	62.00	50.00

The first lot of hay was somewhat less digestible than was the second lot, probably due to the stage of growth at time of cutting. The digestion coefficients compare quite closely with those obtained in previous experiments with similar hay.

Dried Beet Pulp and Molasses Dried Beet Pulp.

Both of these products are the dried residue from the manufacture of sugar from the sugar beet. Molasses dried beet pulp differs from the plain dried beet pulp in containing a considerable proportion of the residual molasses, probably about 25 per cent. The first-named product is noticeably darker in color.

Summary of Coefficients, Dried Beet Pulp, Series XVI., Period III.; Series XVII., Period V.

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.,	1	1	76.72	32.56	49.97	83.56	90.00	–
II.,	1	1	71.45	18.59	55.47	67.03	86.84	–
III.,	1	1	75.56	–	50.14	99.76	73.59	–
Average,	1	3	74.58	–	51.86	83.45	83.48	–

Summary of Coefficients, Molasses Dried Beet Pulp, Series XVI., Period II.; Series XVII., Period V.

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.,	1	1	84.64	55.96	59.87	88.63	91.02	–
II.,	1	1	79.57	36.01	50.19	77.77	89.23	–
IV.,	1	1	82.80	61.06	73.53	64.56	91.37	–
Average,	1	3	82.34	51.01	61.20	76.99	90.54	–

The digestibility of the molasses pulp was about 8 per cent. higher than that of the plain pulp, due to the molasses which is, in all probability, entirely digestible. While beet pulp contains 15 to 18 per cent. of fiber, its digestibility is much higher than that of wheat bran or ground oats, due to its soft, unlignified character. For Sheep III. in the experiment with plain beet pulp, the fiber digestibility is very high, with a corresponding depression in the digestibility of the nitrogen-free extract. It is believed that this condition is abnormal, and that the average of the coefficients for Sheep I. and II. would

be more accurate. The digestibility of the ash in the plain pulp is uncertain, due, partly at least, to the small amount present. There being only about ½ per cent. of ether extract (fat) in beet pulp, it is not possible to secure digestion coefficients for that ingredient. From the variations noted in the digestibility of the different ingredients it is evident that the several sheep differed in their ability to make use of the different nutrients.

Cocoanut Meal.

This product is the residue from the manufacture of cocoanut oil, and is used largely in European countries. It contains about 20 per cent. of protein and 8 to 10 per cent. of fat and some 9 to 10 per cent. of fiber. The sample used was purchased from the Edible Oils Company of New York.

Summary of Coefficients, Cocoanut Meal, Series XVII., Periods II. and VII.

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
V.,	1	1	78.34	63.63	89.59	-	84.59	102.41
VI.,	1	2	83.74	64.24	89.92	23.36	88.56	102.91
Average,	1	3	81.94	64.04	89.81	-	87.24	102.74
European results,[1]	3	5	80.00[2]	-	78.00	63.00	83.00	97.00

[1] Kellner's tabulation. [2] Organic matter.

This material shows a somewhat higher digestibility than the average of European trials, due partly to its less fiber content.

The digestibility of the fiber varied to such an extent as to warrant the elimination of the fiber coefficient, Sheep V. showing a slightly negative result, and the two trials with Sheep VI. showing 7.01 and 39.71 per cent., respectively. It seems probable that the addition of the cocoanut meal to the hay improved the digestibility of the hay fiber, which accounts for the apparently negative or variable fiber coefficients of the cocoanut meal. The ash, protein, extract matter and fat all show a high digestibility, and indicate this material to be a valuable protein concentrate.

Cottonseed Feed Meal, Creamo Brand.

This product consists of a mixture of high-grade cottonseed meal and cottonseed hull bran, the latter being the cottonseed hull from which the lint has been removed.

Summary of Coefficients, Cottonseed Feed Meal, Creamo Brand, Series XVII., Period III.

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
V.	1	1	59.30	47.20	73.57	32.31	61.35	102.97
VI.,	1	1	57.15	51.53	76.34	19.88	61.04	98.25
Average,	1	2	58.23	49.37	74.96	26.10	61.20	100.66
High-grade cottonseed meal for comparison.	4	12	79.00	84.00	84.00	35.00	78.00	94.00

The digestion coefficients in this experiment agreed closely except for fiber. The fiber coefficient was, however, low in both instances, as was to be expected because of the tough, woody character of the hull. This material contains only about three-fourths of the total digestible dry matter of cottonseed meal of good quality. Furthermore, since it contains much less digestible protein, and two and one-half times as much total fiber as genuine cottonseed meal, it is not worth more than one-half as much for animal feeding. In fact, the northern farmer cannot afford to purchase it at present prices in place of the genuine article.

Wheat Screenings.

Wheat screenings consist of the light wheat seed, weed seeds, chaff and dirt separated from the grain as it comes to the mill in preparing the wheat for the manufacture of flour. Their composition depends upon the kind of seeds predominating and upon the amount of dirt and chaff present. They necessarily vary so much in composition that no general statement as to their nutritive value can be made, and the figures reported below should not be understood as applying to all wheat screen-

ings. The two lots used in the present experiments were quite similar in appearance and chemical composition, and were free from an excessive amount of straw and chaff. In the first sample the following seeds and ingredients were identified: light oats, oat hulls, wheat, wheat refuse, smutted grain, yellow foxtail, green foxtail, corn cockle, bindweed, flax, lady's-thumb, charlock, wild mustard, rape, lamb's-quarters, large smartweed, chaff of various sorts, wild sunflower, pigweed, timothy, shepherd's-purse, chess, oat grass, wild oats, rye and corn, together with a few unidentified seeds. Screenings are found in the eastern markets principally as an ingredient of molasses feeds. Both lots were coarsely ground before feeding.

Summary of Coefficients, Wheat Screenings, Series XVII., Period IV. (Lot I.).

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
V.,	1	1	57.57	27.36	78.88	-	63.76	86.18
VI.,	1	1	60.65	26.10	82.97	-	65.33	87.41
Average,	1	2	59.11	26.73	80.93	-	64.55	86.80

Summary of Coefficients, Wheat Screenings, Series XVII., Period X. (Lot II.).

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
V.,	1	1	64.93	-	62.26	-	79.54	87.67
VI.,	1	1	68.58	-	63.01	-	84.12	92.50
Average,	1	2	66.76	-	62.64	-	81.83	90.09
Average for both trials,	2	4	62.94	-	71.79	-	73.19	88.45

The difference shown in the digestibility of the two lots can probably be accounted for by the fact that the first lot contained more fiber and less nitrogen-free extract than did the second. In both trials the fiber coefficient showed that slightly less fiber was digested than when the hay was fed alone, indicating somewhat of a depressing effect of the wheat screenings upon fiber digestibility, and also that the fiber contained in the screenings was of decidedly inferior character. The screenings

contain a high ash content, but the small amount digested shows it to be of comparatively little value.

The experiment indicates that screenings, when finely ground and reasonably free from dirt, chaff and noxious seeds, possess considerable nutritive value. It is likely to be found primarily in the protein and extract matter of the screenings.

Flax Shives.

Flax shives, sometimes incorrectly called flax bran, consists of the ground refuse stalks and pods of the flax plant. It is found on the market as a component of some molasses and stock feeds.

Summary of Coefficients, Flax Shives, Series XVII., Period VI.

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
V.,	1	1	42.94	21.86	79.98	22.00	41.27	92.26
VI.,	1	1	47.82	23.69	82.08	29.58	45.63	93.09
Average,	1	2	45.38	22.78	81.03	25.79	43.45	92.68

This experiment showed flax shives to have a digestibility of about 45 per cent. as compared with 66 per cent. for wheat bran. It contained nearly 35 per cent. of fiber of which about one-fourth proved digestible, and must be pronounced as distinctly inferior for feeding.

Cocoa Shells.

Cocoa shells are the hard, outside coating or bran of the cocoa bean. Up to the present time they have been used but little as a feedstuff, although their chemical composition would indicate that they have considerable feeding value. Preliminary feeding experiments have shown them to be rather unpalatable.

Summary of Coefficients, Cocoa Shells, Series XVII., Period IX.

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.,	1	1	56.55	13.04	4.41	41.41	75.75	100.44
II.,	1	1	58.59	14.32	18.52	59.91	71.16	100.54
Average,	1	2	57.52	13.64	11.47	50.66	73.46	100.48

The coefficients for both sheep agree closely except for protein. In both cases, however, the protein coefficient is extremely low, due, perhaps, to the presence of considerable vegetable alkaloid. It is doubtful if they have more than one-half the value of corn meal. Their use will be more fully discussed elsewhere.

Brook Farm Hay.

This hay was purchased at the Brook Farm, just north of the station grounds, and consisted of a mixture of timothy, red top and clover in good condition. Sheep I. and II. left a considerable portion, Sheep I. refusing the finer portion and Sheep II. the coarser part. In a later trial Sheep V. was induced to eat the entire ration. It was used in connection with a feeding experiment.

Summary of Coefficients, Brook Farm Hay, Series XVIII., Periods VIII. and XIV.

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.,	1	1	61.70	48.19	49.03	69.80	61.15	42.40
II.,	1	1	58.45	45.21	51.40	64.99	57.77	39.11
V.,	1	1	57.03	34.44	50.70	59.77	57.51	38.29
Average,	1	3	59.06	42.61	50.38	64.85	58.81	39.93
Average all trials, mixed hay for comparison.	5	10	55.00	30.00	47.00	65.00	59.00	45.00

The experiment shows this particular lot of hay to compare favorably with all previous trials of mixed hay composed of similar grasses.

CXX Feed.

This feed is a product from the Postum Cereal Company's works, and is probably the residue from the manufacture of Instant Postum, prepared by roasting a mixture of wheat, wheat bran and molasses.

Summary of Coefficients, CXX Feed, Series XVIII., Period IX.

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
V.,	1	1	45.73	–	19.85	20.00	64.97	77.26
VI.,	1	1	40.08	–	19.76	6.76	59.98	78.53
Average,	1	2	42.91	–	19.81	13.39	62.48	77.90

The results of the experiment show the CXX Feed to have a very low digestibility, probably due to the roasting that the product undergoes. The protein and fiber appear to be of little nutritive value, and the material as a whole must be pronounced quite inferior for feeding purposes.

Fish Meals.

Two varieties of fish meal were used in these experiments. The first, Gloucester fish meal, was received from the Russia Cement Company, and is a by-product from the manufacture of fish glue. The second is a by-product from the menhaden fisheries, and up to the present time has been used almost entirely as a fertilizer. It had not been treated with sulphuric acid. The fish guano contained more fat and less ash and protein than did the Gloucester fish meal. In some European countries dried fish and even the raw refuse is used as a food for domestic animals.

Summary of Coefficients, Gloucester Fish Meal, Series XVIII., Period X.

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.,	1	1	53.44	27.61	73.20	-	-	98.12
II.,	1	1	81.99	29.55	77.08	-	-	104.51
Average,	1	2	67.72	28.58	75.14	-	-	101.32

Summary of Coefficients, Wilcox Fish Guano, Series XVIII., Period XII.

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.,	1	1	77.78	41.30	85.23	-	-	111.96
II.,	1	1	71.38	22.81	76.96	-	-	104.09
Average,	1	2	74.58	32.06	81.10	-	-	108.03

The nutritive ratio of the basal ration of hay and corn meal was as 1:10. It would have been better had the basal ration consisted of hay and some nitrogenous concentrate with a ratio of 1:7 or thereabouts, for it is well known that a highly nitrogenous concentrate added to a basal ration with a wide nutritive ratio (1:8 or above) has a tendency to improve the digestibility of the fiber and extract matter of the latter, and would indicate an apparent increase in the digestibility of the fish.

Gloucester Fish Meal. — In case of Sheep I.,[1] the addition of the fish to the basal ration did not appear to improve the digestibility of the carbohydrates, although it may have had a favorable effect upon the protein of the basal ration. In case of Sheep II. it exerted a noticeably favorable effect upon both the fiber and extract, and perhaps upon the protein of the basal ration.

Wilcox Fish Guano. — Sheep II. did not digest as much of the bone (ash) as did Sheep I. The fish seemed to exert a slightly favorable effect upon the fiber, but an adverse effect upon the extract matter. The addition of the fish did improve the digestibility of the fat in the basal ration.

[1] The coefficients with this sheep were not satisfactory.

It is intended to repeat these experiments, using a basal ration with a narrower ratio.

The two samples of fish were composed of approximately 20 per cent. ash, from 60 to 70 per cent. protein, and 3 and 10 per cent. fat, respectively. Its chief value, from a nutritive standpoint, consists in the amount of digestible protein and fat. In view of the prices usually prevailing for fish, it is doubtful if it would prove particularly economical as a food for animals in place of nitrogenous concentrates of vegetable origin.

Molassine Meal.

This is an English product now being extensively sold in Massachusetts. It is composed of from 25 to 30 per cent. of sphagnum moss and from 70 to 75 per cent. of cane or beet molasses. The moss, according to the manufacturers, comes from the upper layers of large bogs in Yorkshire, Eng. Such material, as time passes, decays and forms peat. A sample of the dried sphagnum moss was found to analyze as follows: —

	Per Cent.
Water,	11.45
Protein,	2.72
Fat,	1.18
Nitrogen-free extract,	43.82
Fiber,	39.74
Ash,	1.09

It is doubtful if the moss has any particular nutritive properties;[1] hence, the nutritive value of the feed consists in the amount of molasses present. The larger part of the crude protein found in Molassine meal exists in the form of amids.

[1] Kellner and Pfeiffer have shown that peat is without nutritive value.

Summary of Coefficients, Molassine Meal, Series XVIII., Periods XI. and XIV.; Series XIX., Period I.

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.,[1]	1	1	59.47	65.31	27.19	14.61	71.30	11.34
V.,[2]	1	1	58.54	78.47	58.10	-	70.84	72.13
V.,[1]	1	1	66.60	86.95	32.51	25.00	75.32	-
VI.,[2]	1	1	64.44	87.85	66.33	-	70.91	63.11
VI.,[1]	1	1	60.86	78.83	24.55	-	71.12	-
Average,	1	5	61.98	79.48	41.74	-	71.90	-

[1] Fed with English hay. [2] Fed with English hay and gluten feed.

In three trials the basal ration was English hay; in two other trials English hay and gluten feed were used. Inasmuch as it contains practically no fat, and that its nitrogen is in the amido form, its chief nutritive value is to be found in the carbohydrates. On the basis of the digestibility and at the same moisture content, Molassine meal would have scarcely two-thirds of the nutritive value of corn meal.[1]

Mellen's Food Refuse.

This material is sold to a limited extent in Massachusetts and consists of the residue resulting from the manufacture of an infant food. The original ingredients used in the food are barley, malt, flour and bran.

Summary of Coefficients, Mellen's Food Refuse, Series XVIII., Period XIII.

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
V.,	1	1	54.13	-	50.64	42.83	61.85	83.33
VI.,	1	1	48.17	-	39.24	46.23	54.87	83.43
Average,	1	2	51.15	-	44.94	44.53	58.36	83.38

[1] See also Bulletin 146, p. 58.

Mellen's Food refuse shows a total digestibility only of about 51 per cent., which is lower than would be obtained for any of the ingredients used in the manufacture of the food. This is due, no doubt, to the fact that the more digestible parts are to be found in the food itself.

Complete Summary of All Coefficients (Per Cent.).

Food.	Sheep.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
English hay, Series XVI. and part of Series XVII.	I.,	62.92	32.24	54.53	69.00	65.85	54.06
	II.,	59.36	27.27	52.79	62.91	63.51	54.68
	V.,	61.39	31.98	53.98	66.67	64.62	48.25
	VI.,	63.03	35.61	56.42	68.98	65.50	47.48
Average,		61.68	31.78	54.43	66.89	64.87	51.12
English hay, part of Series XVII., Series XVIII. and XIX.	I.,	66.30	33.10	60.42	71.58	68.02	53.93
	II.,	64.61	29.02	61.53	69.09	66.61	51.73
	V.,	64.22	47.52	64.46	66.37	66.00	48.83
	VI.,	65.41	44.08	64.88	68.36	67.93	42.70
Average,		65.14	38.43	62.82	68.85	67.14	49.30
Dried beet pulp,	I.,	76.72	32.56	49.97	83.56	90.00	–
	II.,	71.45	18.59	55.47	67.03	86.84	–
	III.,	75.56	–	50.14	99.76	73.59	–
Average,		74.58	25.58	51.86	83.45	83.48	–
Molasses dried beet pulp,	I.,	84.64	55.96	59.87	88.63	91.02	–
	II.,	79.57	36.01	50.19	77.77	89.23	–
	IV.,	82.80	61.06	73.53	64.56	91.37	–
Average,		82.34	51.01	61.20	76.99	90.54	–
Cocoanut meal,	V.,	78.34	63.63	89.59	–	84.59	102.41
	VI.,	83.74	63.98	94.84	7.01	89.29	104.47
	VI.,	83.74	64.50	85.00	39.71	87.83	101.35
Average,		81.94	64.04	89.81	23.36	87.24	102.74
Cottonseed feed meal, Creamo brand,	V.,	59.30	47.20	74.28	32.31	61.35	102.97
	VI.,	57.15	51.53	76.34	19.88	61.04	98.25
Average,		58.23	49.37	75.31	26.10	61.20	100.61
Wheat screenings,	V.,	57.57	27.36	78.88	–	63.76	86.18
	VI.,	60.65	26.10	82.97	–	65.33	87.41
Average,		59.11	26.73	80.93	–	64.55	86.80
Wheat screenings,	V.,	64.93	–	62.26	–	79.54	87.67
	VI.,	68.58	–	63.01	–	84.12	92.50
Average,		66.76	–	62.64	–	81.83	90.09

Complete Summary of All Coefficients (Per Cent.) — Concluded.

Food.	Sheep.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Flax shives,	V.,	42.94	21.86	79.98	22.00	41.27	92.26
	VI.,	47.82	23.69	82.08	29.58	45.63	93.09
Average,	.	45.38	22.78	81.03	25.79	43.45	92.68
Cocoa shells,	I.,	56.55	13.04	4.41	41.41	75.75	100.41
	II.,	58.49	14.23	18.52	59.91	71.16	100.54
Average,	.	57.52	13.64	11.47	50.66	73.46	100.48
English hay and corn meal (5½ to 1),[1]	I.,	71.34	47.40	63.34	72.45	74.97	61.58
	II.,	68.83	37.95	62.65	69.07	73.39	55.80
Average,	.	70.09	42.68	63.00	70.76	74.18	58.69
Brook Farm hay,	I.,	61.70	48.19	49.03	69.80	61.15	42.40
	II.,	58.45	45.21	51.40	64.99	57.77	39.11
	V.,	57.03	34.44	50.70	59.77	57.51	38.29
Average,	.	59.06	42.61	50.38	64.85	58.81	39.93
CXX Feed, Postum Cereal refuse,	V.,	45.73	–	19.85	20.01	64.97	77.26
	VI.,	40.08	–	19.76	6.76	59.98	78.53
Average,	.	42.91	–	19.81	13.39	62.48	77.90
Gloucester fish meal,	I.,	53.44	27.61	73.20	–	–	98.12
	II.,	81.99	29.55	77.08	–	–	104.51
Average,	.	67.72	28.58	75.14	–	–	101.32
Wilcox fish guano,	I.,	77.78	41.30	85.23	–	–	111.96
	II.,	71.38	22.81	76.96	–	–	104.09
Average,	.	74.58	32.06	81.10	–	–	108.03
Molassine meal,	I.,	59.47	65.31	27.19	14.61	71.30	11.34
	V.,	58.54	78.47	58.10	–	70.84	72.13
	V.,	66.60	86.95	32.51	25.00	75.32	–
	VI.,	64.44	87.85	66.33	–	70.91	63.11
	VI.,	60.86	78.83	24.55	–	71.12	–
Average,	.	61.98	79.48	41.74	–	71.90	–
Mellen's Food refuse,	V.,	54.13	–	50.64	42.83	61.85	83.33
	VI.,	48.17	–	39.24	46.23	54.87	83.43
Average,	.	51.15	–	44.94	44.53	58.36	83.38
English hay and gluten feed (550 to 150 grams).	V.,	66.13	34.59	67.91	64.67	69.82	56.13
	VI.,	66.61	27.03	68.79	66.60	70.21	56.53
Average,	.	66.37	30.81	68.35	65.64	70.02	56.33

[1] Parts by weight.

A SUMMARY OF METEOROLOGICAL RECORDS.

Location and Equipment.

The meteorological observatory is located in the tower at the southeast corner of South College, at an elevation of about 50 feet above the ground. It was equipped with a number of Draper self-recording instruments, and the records date from Jan. 1, 1889. The location is on a gravel ridge with an open exposure to the north, west and southwest, with slightly higher ground about a mile to the south and a ridge considerably higher about half a mile to the east.

The top of the tower is 72 feet above the ground, and the exposure is good in all directions. The anemometer, anemoscope, wind-pressure instrument and electrical sunshine recorder are mounted from 3 to 5 feet above the top of the tower, and the recording apparatus is in the room below. The thermometer shelter and rain gauges are on the campus about 300 feet southwest from the tower and on slightly lower ground.

The observatory is in latitude 42° 23′ 48.5″ N., longitude 72° 31′ 10″ W., and the base of the tower is 223 feet above mean low water, Boston harbor, as determined by levels connecting with those of the Boston & Maine Railroad. The standard barometer is of United States Weather Bureau pattern, reading to $\frac{1}{500}$ of an inch, and the cistern is 273½ feet above sea level. The Draper self-recording barometer is mounted 1 foot higher.

The sunshine recorder of the Draper pattern was replaced by an electrical one from Friez in 1906, and the Draper anemometer by one of United States Weather Bureau pattern at about the same time. These records are received on a triple register, which also records the rainfall. The rain gauges are about 2 feet above ground and 218 feet above sea level. A United States Weather Bureau gauge is used in determining the pre-

cipitation, and the tipping bucket electrical recording gauge in determining the time and rate.

The Draper self-registering thermometer, Weather Bureau pattern, maximum and minimum thermometers and hygrometer are in a standard shelter about 4 feet above ground and 220 feet above sea level.

On Jan. 1, 1904, the time of making observations was changed from 7 A.M., 2 P.M. and 9 P.M. to 8 A.M. and 8 P.M., so as to conform with the practice of the United States Weather Bureau. This change should be noted in comparing the dew point and relative humidity before and after that date. Other data are probably not affected by the change.

Mean Barometer.

[Readings are reduced to freezing and sea level.]

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean Annual.
1889, . .	30.11	30.24	29.84	29.80	29.92	29.96	29.91	30.01	30.00	30.05	30.04	30.14	30.00
1890, . .	30.19	30.10	29.99	30.10	29.96	29.98	30.02	30.00	30.12	29.88	30.01	30.01	30.03
1891, . .	29.96	30.04	30.10	29.92	29.98	29.92	29.99	29.96	30.11	30.03	30.12	30.08	30.02
1892, . .	29.96	30.11	29.90	29.97	29.94	29.92	29.99	30.02	30.10	29.90	29.99	30.01	29.98
1893, . .	29.95	30.11	30.06	30.09	29.90	30.06	29.97	30.00	30.06	30.13	30.12	30.12	30.05
1894, . .	30.18	30.16	30.09	30.05	30.00	30.00	30.01	30.03	30.14	30.02	30.08	30.15	30.08
1895, . .	30.05	29.92	30.00	30.12	30.10	30.17	30.03	30.02	30.10	30.08	30.19	30.15	30.08
1896, . .	30.16	29.86	29.99	30.14	29.98	29.95	29.97	29.99	30.00	30.01	30.14	30.14	30.03
1897, . .	30.04	30.06	30.04	30.04	29.92	29.90	29.94	29.94	30.09	30.12	30.03	30.04	30.01
1898, . .	29.98	30.05	30.20	29.93	29.94	29.95	30.02	29.96	30.01	30.09	30.01	29.96	30.01
1899, . .	30.11	29.98	29.94	30.04	30.00	29.98	29.93	29.98	30.02	30.19	30.01	30.03	30.02
1900, . .	30.03	29.97	29.95	29.96	29.91	29.91	29.91	29.99	30.04	30.15	29.99	30.03	29.98
1901, . .	29.95	29.79	29.90	29.97	29.88	29.95	29.93	30.02	30.03	30.08	29.93	30.03	29.96
1902, . .	30.04	29.78	29.91	29.88	29.84	29.84	29.96	29.92	30.04	30.03	30.06	30.06	29.95
1903, . .	29.91	29.98	30.20	29.87	29.94	29.94	29.88	30.00	30.10	30.00	30.01	29.97	30.00
1904, . .	30.08	30.11	30.11	29.97	30.02	30.02	29.98	30.03	30.08	30.08	29.95	30.02	30.03
1905, . .	30.08	30.12	30.12	29.85	29.93	29.93	29.95	29.98	30.05	30.10	30.01	30.08	29.94
1906, . .	30.09	30.20	30.09	29.98	29.94	29.94	29.98	30.02	30.09	30.09	30.04	30.12	30.05
1907, . .	30.23	30.09	30.08	29.88	29.93	29.93	29.87	30.00	30.02	30.05	30.05	30.02	30.02
1908, . .	29.97	30.08	30.10	29.92	30.03	30.03	30.04	30.03	30.10	30.17	30.01	30.04	30.04
1909, . .	30.15	29.96	29.82	30.06	29.94	29.97	29.91	30.02	30.11	30.03	30.16	29.89	30.01
1910, . .	30.11	30.07	30.08	29.97	29.96	29.92	29.89	30.07	30.10	30.01	29.80	30.03	30.00
1911, . .	30.12	30.12	29.99	30.14	30.03	29.94	29.99	30.02	30.06	30.11	30.01	30.15	30.06
1912, . .	30.02	29.93	30.13	29.99	29.96	29.99	29.98	29.95	30.07	30.06	30.00	30.01	30.01
1913, . .	30.10	30.01	30.11	30.02	29.99	30.00	29.94	30.03	30.13	29.97	30.13	30.01	30.04
Mean, .	30.06	30.03	30.03	29.99	29.96	29.96	29.96	30.00	30.07	30.06	30.04	30.05	30.01

Range of Barometer (in Inches).

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Range Annual.
1889, . .	1.62	1.51	1.58	1.16	.75	.97	.68	.66	.98	.96	1.31	1.75	1.81
1890, . .	1.50	1.35	1.08	1.08	.81	.58	.63	1.10	.69	1.09	.98	1.20	1.76
1891, . .	1.93	1.36	1.21	1.42	.79	.53	.74	.61	.73	1.11	1.56	1.22	2.05
1892, . .	1.38	1.65	1.16	1.02	.96	.84	.97	.55	.96	.98	1.00	1.01	1.65
1893, . .	1.53	1.83	1.27	1.25	1.16	.67	.68	.93	.81	1.37	1.16	1.53	1.92
1894, . .	1.89	1.65	1.04	.86	.93	.75	.57	.44	1.11	1.19	1.22	1.23	2.01
1895, . .	1.46	1.88	1.24	1.40	.84	.66	.51	.53	.68	1.09	1.47	1.78	2.27
1896, . .	.97	1.77	1.52	.96	.75	.83	.79	.59	.85	1.10	1.23	1.57	2.22
1897, . .	1.57	1.15	1.74	1.10	.76	.55	.72	.61	.73	1.12	1.48	1.42	1.76
1898, . .	1.43	1.63	1.17	.86	.76	.95	.81	.60	.82	1.19	1.25	1.39	1.75
1899, . .	1.70	1.41	1.54	.90	.60	.59	.51	.56	.88	.76	1.10	1.58	1.82
1900, . .	1.58	1.89	1.52	1.01	.99	.67	.73	.53	1.03	1.07	1.71	1.53	1.89
1901, . .	1.68	.97	1.17	1.19	.77	.61	.59	.51	1.00	1.22	1.14	1.13	1.68
1902, . .	1.49	1.41	1.55	1.04	.94	1.27	.58	.67	.78	1.25	1.12	1.34	1.89
1903, . .	1.49	1.55	1.19	1.15	.85	.97	.57	.77	.78	1.08	1.32	1.56	1.77
1904, . .	1.50	1.36	1.58	1.00	.75	.81	.73	.73	1.20	1.23	1.84	1.43	2.23
1905, . .	1.37	1.28	.89	1.15	.85	.83	.58	.72	.66	1.16	1.22	1.53	1.64
1906, . .	1.53	1.28	1.64	1.05	1.08	.77	.90	.72	1.03	1.41	1.05	1.30	1.70
1907, . .	1.34	1.27	1.39	1.42	.67	.71	.76	.71	.91	1.24	1.59	1.46	1.79
1908, . .	1.73	1.89	1.22	1.35	1.11	.65	.66	.68	.73	1.17	1.14	1.31	1.97
1909, . .	1.64	1.63	1.52	1.14	0.82	.68	.88	.97	.80	.97	1.24	1.54	1.91
1910, . .	1.76	1.40	1.11	.90	1.02	.83	.57	.82	.57	1.05	1.02	1.44	1.76
1911, . .	1.50	1.09	1.77	1.14	.97	.69	.74	.76	.85	1.04	1.24	1.20	1.77
1912, . .	1.60	1.75	1.43	1.32	.86	.64	.89	.77	.75	.87	1.17	1.46	1.98
1913, . .	2.18	.88	1.92	1.06	.87	.80	.65	.72	.83	1.38	1.65	1.34	2.33
Mean, .	1.57	1.47	1.38	1.12	.87	.75	.70	.69	.87	1.12	1.29	1.41	1.89

Maximum Barometer.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Maximum Annual.
1889, . .	30.82	30.97	30.66	30.54	30.40	30.54	30.35	30.45	30.40	30.52	30.67	30.96	30.97
1890, . .	30.94	30.72	30.56	30.57	30.32	30.28	30.27	30.28	30.42	30.41	30.35	30.61	30.94
1891, . .	30.62	30.69	30.57	30.56	30.44	30.22	30.37	30.27	30.45	30.67	30.74	30.55	30.74
1892, . .	30.67	30.72	30.45	30.53	30.43	30.39	30.50	30.24	30.42	30.43	30.44	30.53	30.72
1893, . .	30.61	30.83	30.63	30.65	30.32	30.36	30.25	30.30	30.45	30.65	30.70	30.92	30.92
1894, . .	30.77	30.89	30.57	30.52	30.50	30.33	30.31	30.24	30.63	30.42	30.73	30.53	30.89
1895, . .	30.61	30.44	30.52	30.70	30.55	30.51	30.33	30.29	30.41	30.67	30.73	30.83	30.83
1896, . .	30.56	30.49	30.62	30.60	30.48	30.42	30.49	30.39	30.40	30.62	30.86	30.94	30.94
1897, . .	30.77	30.70	30.88	30.61	30.36	30.28	30.33	30.18	30.40	30.67	30.60	30.60	30.88
1898, . .	30.61	30.64	30.76	30.34	30.33	30.35	30.44	30.26	30.41	30.46	30.53	30.52	30.76
1899, . .	30.92	30.53	30.49	30.39	30.29	30.25	30.24	30.31	30.47	30.50	30.54	30.66	30.92
1900, . .	30.67	30.75	30.59	30.48	30.38	30.19	30.16	30.25	30.35	30.52	30.64	30.51	30.75
1901, . .	30.69	30.34	30.43	30.52	30.20	30.24	30.29	30.28	30.51	30.66	30.37	30.58	30.69
1902, . .	30.66	30.27	30.50	30.28	30.43	30.46	30.29	30.26	30.38	30.52	30.48	30.75	30.75
1903, . .	30.62	30.48	30.65	30.46	30.54	30.39	30.17	30.42	30.42	30.40	30.70	30.60	30.70
1904, . .	30.90	30.67	30.96	30.50	30.37	30.35	30.26	30.42	30.62	30.57	30.57	30.54	30.96
1905, . .	30.70	30.62	30.60	30.37	30.38	30.19	30.15	30.27	30.41	30.58	30.63	30.86	30.86
1906, . .	30.78	30.95	30.92	30.45	30.49	30.35	30.46	30.38	30.50	30.63	30.42	30.77	30.95
1907, . .	30.75	30.78	30.59	30.41	30.34	30.22	30.18	30.35	30.39	30.60	30.59	30.45	30.78
1908, . .	30.59	30.83	30.59	30.52	30.31	30.40	30.26	30.34	30.45	30.59	30.45	30.61	30.83
1909, . .	30.75	30.53	30.36	30.60	30.29	30.26	30.27	30.39	30.52	30.52	30.74	30.58	30.75
1910, . .	30.87	30.80	30.50	30.40	30.40	30.24	30.18	30.37	30.34	30.47	30.40	30.78	30.87
1911, . .	30.66	30.64	30.72	30.71	30.40	30.24	30.26	30.30	30.41	30.59	30.48	30.57	30.72
1912, . .	30.59	30.47	30.70	30.62	30.31	30.31	30.35	30.29	30.37	30.46	30.50	30.61	30.70
1913, . .	30.73	30.44	30.88	30.56	30.39	30.43	30.19	30.41	30.58	30.52	30.72	30.47	30.88
Mean, .	30.71	30.65	30.62	30.52	30.39	30.33	30.29	30.32	30.44	30.55	30.58	30.65	30.83

Minimum Barometer.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Minimum Annual.
1889, . .	29.20	29.46	29.08	29.38	29.65	29.57	29.67	29.79	29.42	29.56	29.36	29.21	29.08
1890, . .	29.44	29.37	29.48	29.49	29.51	29.70	29.64	29.18	29.73	29.32	29.37	29.41	29.18
1891, . .	28.69	29.33	29.36	29.14	29.65	29.69	29.63	29.66	29.72	29.56	29.18	29.33	28.69
1892, . .	29.29	29.07	29.29	29.51	29.47	29.55	29.53	29.69	29.46	29.45	29.44	29.52	29.07
1893, . .	29.08	29.00	29.36	29.40	29.16	29.69	29.57	29.37	29.64	29.28	29.54	29.39	29.00
1894, . .	28.88	29.24	29.53	29.66	29.57	29.58	29.74	29.80	29.52	29.23	29.51	29.30	28.88
1895, . .	29.17	28.56	29.28	29.30	29.71	29.85	29.82	29.76	29.73	29.58	29.26	29.05	28.56
1896, . .	29.59	28.72	29.10	29.64	29.73	29.59	29.70	29.80	29.55	29.52	29.63	29.37	28.72
1897, . .	29.20	29.55	29.14	29.51	29.60	29.63	29.61	29.57	29.67	29.55	29.12	29.18	29.12
1898, . .	29.18	29.01	29.59	29.48	29.57	29.40	29.63	29.66	29.59	29.27	29.28	29.13	29.01
1899, . .	29.22	29.12	28.95	29.49	29.69	29.66	29.63	29.75	29.56	29.74	29.44	29.10	29.10
1900, . .	29.08	28.86	29.06	29.47	29.39	29.51	29.42	29.72	29.32	29.42	28.93	28.98	28.86
1901, . .	29.01	29.37	29.26	29.33	29.43	29.63	29.70	29.76	29.51	29.44	29.23	29.42	29.01
1902, . .	29.17	28.86	28.95	29.24	29.49	29.24	29.61	29.59	29.60	29.27	29.36	29.41	28.86
1903, . .	29.13	28.93	29.46	29.31	29.69	29.42	29.60	29.65	29.69	29.32	29.38	29.04	28.93
1904, . .	29.40	29.31	29.38	29.50	29.62	29.54	29.53	29.69	29.42	29.28	28.73	29.11	28.73
1905, . .	29.33	29.34	29.71	29.22	29.53	29.36	29.57	29.55	29.75	29.42	29.41	29.33	29.22
1906, . .	29.25	29.67	29.28	29.40	29.41	29.58	29.56	29.66	29.47	29.22	29.37	29.47	29.25
1907, . .	29.41	29.51	29.29	28.99	29.69	29.51	29.42	29.64	29.48	29.36	29.00	29.05	28.99
1908, . .	28.86	28.94	29.37	29.27	29.20	29.75	29.69	29.66	29.72	29.42	29.31	29.30	28.86
1909, . .	29.11	28.90	28.84	29.46	29.47	29.58	29.39	29.42	29.72	29.55	29.50	29.04	28.84
1910, . .	29.11	29.40	29.39	29.50	29.38	29.41	29.61	29.55	29.77	29.42	29.38	29.34	29.11
1911, . .	29.16	29.55	28.95	29.57	29.43	29.55	29.52	29.54	29.56	29.55	29.24	29.37	28.95
1912, . .	28.99	28.72	29.27	29.30	29.45	29.67	29.46	29.52	29.62	29.59	29.33	29.15	28.72
1913, . .	28.55	29.56	29.26	29.50	29.52	29.63	29.54	29.69	29.75	29.14	29.07	29.13	28.55
Mean, .	29.14	29.17	29.27	29.40	29.52	29.57	29.59	29.63	29.60	29.42	29.29	29.25	28.93

Mean Hourly Temperature.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889, . .	32.9	23.9	37.9	49.3	61.4	67.7	69.5	65.5	61.9	46.5	41.9	35.0	49.5
1890, . .	32.1	31.7	31.9	46.5	57.1	65.3	69.8	67.2	59.7	48.5	38.0	22.9	47.6
1891, . .	27.6	29.6	33.7	49.4	57.3	66.6	68.2	70.2	65.3	49.9	39.7	38.3	49.7
1892, . .	25.3	28.4	33.1	48.7	56.1	70.3	72.2	70.0	60.6	50.8	39.3	28.5	48.6
1893, . .	19.0	25.7	33.4	44.7	58.7	69.0	71.4	71.0	58.1	53.9	40.1	28.2	47.8
1894, . .	28.7	25.5	41.6	47.9	58.7	69.4	73.5	69.3	64.8	52.1	36.4	28.5	49.7
1895, . .	25.0	22.3	33.0	46.9	61.3	70.5	69.3	70.4	63.8	48.1	41.1	29.0	48.4
1896, . .	23.2	30.0	29.4	49.2	62.4	65.0	70.7	68.2	59.3	46.4	41.9	25.3	49.3
1897, . .	24.2	25.1	32.9	46.5	57.1	61.8	70.5	66.0	59.8	49.9	36.9	28.8	46.6
1898, . .	21.8	26.3	39.6	43.0	55.6	66.0	70.9	69.7	63.0	51.1	37.3	26.2	47.5
1899, . .	23.3	21.8	30.6	46.1	55.7	67.4	70.1	68.0	59.7	51.1	37.0	30.8	46.8
1900, . .	25.5	24.6	29.5	46.9	55.4	67.1	70.6	70.1	63.8	54.5	41.3	30.6	48.3
1901, . .	23.7	20.1	33.1	46.8	56.2	68.0	72.5	69.9	62.1	50.1	33.4	26.4	46.9
1902, . .	22.9	25.5	40.5	47.3	57.0	63.5	67.8	66.1	60.3	50.7	42.8	23.5	47.3
1903, . .	24.3	27.3	42.6	46.9	59.2	59.6	68.9	62.0	61.3	51.1	34.3	22.5	46.7
1904, . .	14.3	17.7	31.0	42.5	60.1	65.0	69.8	66.4	59.8	47.2	33.0	19.6	43.9
1905, . .	20.4	17.7	33.1	45.6	56.9	64.4	71.1	65.8	59.1	49.9	36.3	29.8	45.8
1906, . .	29.6	23.8	28.3	45.1	56.7	66.1	70.1	70.5	64.0	50.5	38.5	24.2	47.3
1907, . .	22.4	16.5	35.2	41.5	51.8	63.9	70.0	66.1	61.3	45.6	37.6	30.5	45.2
1908, . .	25.7	20.5	34.7	45.1	59.2	67.6	72.5	66.6	62.9	51.3	38.0	27.1	47.6
1909, . .	25.7	28.1	32.4	44.4	55.5	66.4	68.7	66.5	60.5	47.7	41.3	24.7	46.8
1910, . .	25.5	23.9	39.1	50.6	56.1	63.8	72.1	67.1	61.1	51.7	36.4	21.7	47.4
1911, . .	27.4	23.3	31.5	43.7	61.9	64.5	73.7	67.8	60.2	48.5	36.7	32.7	47.6
1912, . .	14.6	20.7	30.5	45.2	58.1	65.0	71.6	66.4	61.2	52.4	40.0	32.9	46.5
1913, . .	33.6	22.7	37.9	47.6	55.6	66.4	71.4	69.5	59.7	54.7	41.6	31.3	49.3
Mean, .	24.7	24.1	34.1	46.3	57.6	66.0	70.7	67.9	61.3	50.2	38.6	28.0	47.5

Range of Temperature (in Degrees F.).

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Range
1889, . .	48.0	49.0	40.0	46.0	50.0	44.0	31.0	37.0	41.0	43.0	41.0	57.5	92.0
1890, . .	57.0	54.5	69.0	57.5	48.5	47.5	54.0	47.0	52.0	52.0	51.0	48.5	100.5
1891, . .	52.5	60.0	57.5	61.5	62.0	60.0	48.5	47.5	55.5	69.0	60.5	51.5	100.0
1892, . .	66.5	53.5	54.5	58.5	56.0	54.0	52.0	44.0	49.0	54.5	53.0	47.0	104.5
1893, . .	63.0	54.5	48.0	48.5	57.0	52.5	49.5	57.0	51.0	57.0	52.0	64.0	109.0
1894, . .	52.0	66.0	56.0	63.0	56.0	55.5	50.0	54.0	56.0	43.0	55.0	55.0	115.0
1895, . .	50.0	55.0	44.0	56.0	62.5	51.0	54.0	52.0	64.0	51.0	57.0	68.0	105.0
1896, . .	53.0	67.0	52.0	67.5	62.5	51.0	41.0	55.0	57.5	49.0	54.0	62.0	111.0
1897, . .	51.0	59.0	60.5	60.0	48.0	47.5	36.0	43.0	59.5	63.5	58.0	62.5	102.5
1898, . .	65.5	73.0	45.5	54.0	46.0	50.0	56.5	46.5	58.5	59.5	56.0	60.0	115.5
1899, . .	70.5	61.0	42.0	61.0	55.5	51.0	47.0	51.0	51.5	61.5	40.5	59.0	114.5
1900, . .	56.0	64.0	46.0	59.0	67.5	54.0	51.0	53.0	53.5	61.0	55.0	57.5	104.0
1901, . .	55.0	48.5	57.0	58.5	50.5	57.5	52.0	33.5	59.0	51.0	54.0	70.5	111.0
1902, . .	47.5	49.0	48.5	57.5	61.0	49.0	45.0	44.0	51.5	51.5	47.5	64.0	106.0
1903, . .	57.5	68.0	57.0	62.0	68.0	48.5	52.5	42.0	60.5	55.0	68.5	61.5	109.0
1904, . .	66.0	56.0	68.0	50.5	48.0	51.5	48.0	49.5	58.5	59.5	49.0	47.0	120.5
1905, . .	64.0	59.5	76.0	57.0	50.5	54.0	47.0	47.5	53.0	59.0	50.0	51.5	106.0
1906, . .	56.5	57.5	60.5	53.5	58.5	50.5	43.5	43.0	59.5	53.5	43.5	48.5	98.5
1907, . .	78.0	61.5	74.0	49.0	65.0	57.0	46.0	55.0	49.0	52.5	40.5	50.5	119.5
1908, . .	58.5	68.0	62.0	66.0	55.0	55.5	50.5	51.5	55.0	67.5	39.5	63.5	108.0
1909, . .	61.0	57.5	41.0	61.0	49.0	51.5	51.0	56.0	48.0	61.0	53.5	60.0	102.5
1910, . .	65.0	60.5	65.5	56.0	53.0	53.0	48.5	44.5	48.0	65.0	46.0	49.0	106.0
1911, . .	49.0	54.5	56.5	68.0	67.5	45.0	55.0	50.0	55.0	48.5	48.0	52.0	107.0
1912, . .	64.0	66.0	59.5	54.0	55.5	55.0	57.5	50.0	51.0	56.5	48.5	62.0	117.5
1913, . .	48.5	59.5	73.0	62.0	58.5	55.0	59.0	56.0	56.5	54.5	45.0	48.0	104.5
Mean, .	58.2	59.3	56.5	57.9	56.5	52.0	49.0	48.4	54.1	56.0	50.7	56.8	107.6

Maximum Temperatures (in Degrees F.).

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Maximum Annual.
1889, . .	56.0	47.0	61.0	78.0	88.0	90.0	85.0	82.0	81.0	69.0	61.0	63.0	90.0
1890, . .	61.5	57.5	62.5	79.5	80.0	88.0	94.0	88.5	80.5	78.0	62.5	43.5	94.0
1891, . .	52.0	54.0	56.5	79.5	87.0	94.0	90.0	92.5	91.5	89.0	64.0	60.5	94.0
1892, . .	57.0	46.5	60.5	78.5	84.0	95.0	94.0	94.0	80.0	77.5	67.0	46.0	95.0
1893, . .	50.0	50.0	52.0	67.5	87.0	94.0	90.5	96.0	81.0	80.0	63.0	52.0	96.0
1894, . .	53.0	49.0	73.0	79.0	85.0	93.0	98.0	91.0	91.0	75.0	65.0	51.0	98.0
1895, . .	45.5	45.0	49.0	81.0	92.0	95.0	90.0	90.0	97.0	71.0	72.0	65.0	97.0
1896, . .	41.0	53.0	57.0	88.5	94.5	90.0	91.0	97.0	88.5	72.0	69.0	52.5	97.0
1897, . .	51.0	48.0	59.0	80.5	79.5	85.5	91.0	85.0	91.5	84.0	63.0	59.0	91.5
1898, . .	50.0	54.0	60.0	71.0	78.5	89.5	96.5	91.0	93.0	86.5	62.0	48.0	96.5
1899, . .	49.0	51.0	52.0	82.0	88.5	93.0	90.0	92.0	84.0	82.0	58.0	61.0	93.0
1900, . .	51.5	56.0	49.0	80.8	91.5	94.0	95.5	96.0	89.0	83.0	67.0	58.0	96.0
1901, . .	47.0	44.0	56.5	86.5	82.0	98.5	100.5	86.5	92.0	75.0	60.0	60.0	100.5
1902, . .	47.0	54.0	65.0	83.0	91.0	89.0	90.0	87.0	86.5	74.0	65.0	49.0	91.0
1903, . .	45.5	57.0	76.0	84.0	92.5	86.5	97.0	84.5	91.0	77.5	74.5	52.0	97.0
1904, . .	40.0	48.0	65.0	70.5	85.0	92.5	94.5	89.5	84.5	77.5	56.5	43.5	94.5
1905, . .	51.0	48.5	77.0	79.0	82.5	90.0	93.0	89.0	85.0	80.5	61.0	54.5	93.0
1906, . .	60.0	52.5	53.0	74.5	90.0	87.5	88.5	90.5	91.0	77.5	62.0	45.5	91.0
1907, . .	54.5	43.0	79.5	70.5	90.0	95.0	90.0	96.0	85.0	73.0	60.0	60.5	96.0
1908, . .	53.0	56.0	67.0	84.0	88.5	91.5	96.0	88.5	88.0	90.5	58.0	65.5	96.0
1909, . .	54.0	54.5	54.0	80.0	81.5	91.5	93.0	94.0	83.0	85.0	72.0	51.5	94.0
1910, . .	56.0	53.5	78.0	80.0	84.0	88.0	97.0	85.5	82.0	84.0	61.0	47.0	97.0
1911, . .	50.5	51.5	59.0	86.0	94.5	89.5	104.0	94.5	84.0	72.5	66.5	62.0	104.0
1912, . .	45.0	49.5	60.5	78.0	88.0	91.0	98.5	89.0	86.0	83.0	67.0	65.0	98.5
1913, . .	59.5	55.0	74.0	84.5	89.0	92.0	100.0	97.0	87.5	79.0	68.0	53.0	100.0
Mean,	51.2	51.1	62.2	79.4	87.0	91.3	93.7	90.7	86.9	79.0	64.2	54.7	95.6

Minimum Temperatures (in Degrees F.).

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Minimum Annual.
1889, . .	8.0	—2.0	21.0	32.0	38.0	46.0	34.0	45.0	40.0	26.0	20.0	5.5	—2.0
1890, . .	4.5	3.0	—6.5	22.0	31.5	40.5	40.0	41.5	28.5	26.0	11.5	—5.0	—6.5
1891, . .	—0.4	—6.0	—1.0	18.0	25.0	34.0	41.5	45.0	36.0	20.0	3.5	9.0	—6.0
1892, . .	—9.5	—7.0	6.0	20.5	28.0	41.0	42.0	50.0	31.0	23.0	14.0	—1.0	—9.5
1893, . .	—13.0	—4.5	4.0	19.0	30.0	41.5	41.0	39.0	30.0	23.0	11.0	—12.0	—13.0
1894, . .	1.0	—17.0	17.0	16.0	29.0	37.5	48.0	37.0	35.0	32.0	10.0	—4.0	—17.0
1895, . .	—4.5	—10.0	5.0	25.0	29.5	44.0	46.0	38.0	33.0	20.0	15.0	—3.0	—10.0
1896, . .	—12.0	—14.0	5.0	21.0	32.0	39.0	50.0	42.0	31.0	23.0	15.0	—9.5	—14.0
1897, . .	0.0	—11.0	—1.5	20.5	31.5	38.0	55.0	42.0	32.0	20.5	5.0	—3.5	—11.0
1898, . .	—15.5	—19.0	14.5	17.0	32.5	39.5	40.0	44.5	34.5	27.0	6.0	—12.0	—19.0
1899, . .	—21.5	—10.0	10.0	21.0	33.0	42.0	43.0	41.0	32.5	20.5	17.5	2.0	—21.5
1900, . .	—4.5	—8.0	3.0	21.0	24.0	40.0	44.5	43.0	35.5	22.0	12.0	0.5	—8.0
1901, . .	—8.0	—4.5	—0.5	28.0	31.5	41.0	48.5	53.0	33.0	24.0	6.0	—10.5	—10.5
1902, . .	—0.5	5.0	16.5	25.5	30.0	40.0	45.0	43.0	35.0	22.5	17.5	—15.0	—15.0
1903, . .	—12.0	—11.0	19.0	22.0	24.5	38.0	44.5	42.5	30.5	22.5	6.0	—9.5	—12.0
1904, . .	—26.0	—8.0	—3.0	20.0	37.0	44.0	46.5	40.0	26.0	18.0	7.5	—3.5	—26.0
1905, . .	—13.0	—11.0	1.0	22.0	32.0	36.0	46.0	41.5	32.0	21.5	11.0	3.0	—13.0
1906, . .	3.5	—5.0	—7.5	21.0	31.5	37.0	45.0	47.5	31.5	24.0	18.5	—3.0	—7.5
1907, . .	—23.5	—18.5	5.5	20.5	25.0	38.0	44.0	41.0	36.0	20.5	19.5	10.0	—23.5
1908, . .	—5.5	—12.0	5.0	18.0	33.5	36.0	46.0	37.0	33.0	23.0	18.5	2.0	—12.0
1909, . .	—7.0	—3.0	13.0	19.0	32.5	40.0	42.0	38.0	35.0	24.0	18.5	—8.5	—8.5
1910, . .	—9.0	—7.0	12.5	24.0	31.0	35.0	48.5	41.0	34.0	19.0	15.0	—2.0	—9.0
1911, . .	1.5	—3.0	2.5	18.0	27.0	44.5	49.0	44.5	29.0	24.0	18.5	10.0	—3.0
1912, . .	—19.0	—16.5	1.0	24.0	32.5	36.0	41.0	39.0	35.0	26.5	18.5	3.0	—19.0
1913, . .	11.0	—4.5	1.0	22.5	30.5	37.0	41.0	41.0	31.0	24.5	23.0	5.0	—4.5
Mean, .	—7.0	—8.2	5.7	21.5	30.5	39.4	45.3	42.3	32.8	23.1	13.5	—2.9	—12.0

Mean Dew Point (in Degrees F.).

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889, . .	26.3	21.2	30.4	43.8	52.8	61.1	62.7	59.5	56.9	39.4	38.3	30.9	43.6
1890, . .	23.8	25.2	26.5	35.6	58.0	57.9	61.5	57.2	55.8	41.0	29.7	14.7	40.6
1891, . .	20.7	21.7	22.6	36.3	44.6	57.0	58.5	62.4	58.1	40.6	30.4	28.2	40.1
1892, . .	18.8	20.9	21.5	33.0	44.9	62.3	60.9	62.1	51.9	41.0	32.1	20.5	39.2
1893, . .	13.9	17.3	24.0	31.4	45.7	58.3	58.8	59.9	49.1	44.2	29.9	21.9	37.9
1894, . .	21.6	17.9	31.1	34.2	52.6	57.9	62.4	58.6	56.2	44.6	27.3	22.3	40.5
1895, . .	19.2	17.1	26.2	35.8	48.7	59.6	59.3	60.4	54.8	35.4	34.4	23.6	39.5
1896, . .	14.3	22.0	25.6	35.9	48.3	53.9	62.4	61.7	54.5	42.4	37.7	19.6	39.9
1897, . .	18.0	18.1	26.9	35.7	48.0	53.3	64.6	59.7	52.7	39.0	31.8	24.2	39.6
1898, . .	18.4	21.8	30.5	34.2	48.8	59.3	64.6	64.6	56.9	46.6	32.7	20.8	41.6
1899, . .	16.6	17.0	25.5	36.5	48.6	59.5	62.5	59.4	51.5	48.8	29.8	25.1	40.1
1900, . .	18.1	17.8	19.3	34.9	43.7	57.0	62.3	62.0	54.7	47.1	32.0	21.7	39.2
1901, . .	16.6	10.6	24.7	35.6	45.7	56.2	63.4	62.3	54.5	39.9	24.1	17.9	37.6
1902, . .	12.3	15.1	32.2	36.3	44.0	53.5	57.3	57.8	53.7	40.5	34.2	15.0	37.7
1903, . .	16.0	21.0	34.6	34.1	44.9	53.7	59.3	54.7	52.5	39.2	25.6	16.1	37.6
1904, . .	9.3	9.5	22.4	31.5	48.4	56.6	61.5	59.0	52.7	37.5	25.1	12.6	35.5
1905, . .	12.8	9.2	24.8	33.5	45.7	56.5	63.2	59.0	52.4	40.3	26.8	23.8	37.3
1906, . .	20.8	15.2	19.3	34.7	46.4	58.3	63.1	63.6	55.2	42.9	27.7	16.5	38.6
1907, . .	13.4	9.0	25.8	32.0	42.2	55.0	61.0	56.5	54.6	37.1	32.0	23.7	36.9
1908, . .	16.5	14.7	26.9	31.9	50.1	56.2	63.7	58.3	53.5	41.8	30.1	18.6	38.5
1909, . .	19.0	21.0	26.0	35.5	45.1	56.6	58.6	57.8	52.6	38.0	32.6	15.8	38.2
1910, . .	18.2	16.9	28.8	39.2	45.5	55.2	61.0	57.4	53.5	41.2	28.2	14.2	38.3
1911, . .	19.7	15.3	22.2	30.1	51.7	55.8	61.7	59.0	52.9	40.1	27.4	23.9	38.3
1912, . .	7.8	12.6	23.4	37.0	50.2	54.5	60.5	58.1	54.3	41.7	31.6	23.5	38.6
1913, . .	25.9	14.1	30.7	38.5	46.0	54.6	59.8	58.6	51.0	46.5	32.1	23.5	40.1
Mean, .	17.5	16.9	26.1	35.1	47.6	56.8	61.4	60.0	53.9	41.5	30.5	20.7	39.0

Mean Relative Humidity.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889, . .	79.0	90.0	75.0	78.3	73.8	79.1	78.2	80.4	83.3	75.7	75.4	75.2	78.6
1890, . .	68.2	74.8	77.3	64.7	67.1	71.3	70.1	74.9	80.9	68.2	67.8	67.2	71.1
1891, . .	72.2	69.4	63.7	60.1	59.3	65.3	66.1	70.3	72.1	65.5	68.7	68.7	66.8
1892, . .	73.7	72.8	64.1	54.5	60.3	68.9	65.6	74.9	70.7	65.5	71.0	70.3	67.7
1893, . .	80.2	74.7	71.4	64.8	66.0	71.1	64.8	70.7	72.8	67.0	68.8	80.9	71.1
1894, . .	78.8	77.5	67.5	60.5	65.8	68.1	68.2	69.9	74.4	82.7	70.8	79.0	71.9
1895, . .	82.5	83.9	80.6	68.1	65.0	68.5	72.7	72.7	73.7	69.2	80.5	75.4	74.4
1896, . .	73.3	87.5	85.3	62.0	62.5	67.3	73.1	79.9	84.0	85.0	82.3	79.8	76.9
1897, . .	77.1	75.7	78.9	68.2	71.5	73.3	80.1	79.6	76.6	68.7	83.2	83.9	76.4
1898, . .	85.2	83.1	72.6	72.1	78.4	77.1	79.3	82.1	80.0	83.6	83.4	80.2	79.8
1899, . .	77.7	82.5	79.1	69.2	70.3	74.0	75.2	74.1	74.0	75.9	76.2	79.4	75.6
1900, . .	75.1	77.4	67.8	64.7	65.5	69.5	71.1	75.9	73.1	77.0	75.9	74.9	72.3
1901, . .	74.3	68.5	70.8	68.1	68.1	65.5	72.3	76.3	76.8	70.5	71.1	69.8	71.0
1902, . .	66.2	66.8	72.3	67.1	63.4	70.8	77.2	76.3	79.1	70.9	75.6	72.5	71.6
1903, . .	72.0	77.7	76.4	64.7	61.3	81.1	71.4	78.2	75.0	74.5	73.5	76.5	73.5
1904, . .	85.5	77.7	74.4	70.8	69.7	77.0	77.7	80.5	81.8	74.0	77.5	77.8	77.0
1905, . .	77.2	75.1	76.7	66.7	68.2	78.8	79.1	82.5	83.2	75.9	73.5	80.6	76.5
1906, . .	74.8	77.4	73.9	70.3	70.9	79.1	82.4	82.9	80.1	84.1	72.2	77.0	77.1
1907, . .	76.1	80.2	73.4	74.1	75.3	76.9	76.4	74.9	83.0	77.7	85.9	80.4	77.9
1908, . .	73.8	84.8	77.9	64.3	74.8	66.2	76.6	79.0	79.1	79.0	79.6	75.1	75.8
1909, . .	78.5	78.9	81.3	76.3	71.2	73.6	71.8	78.1	83.1	76.1	77.2	75.2	76.8
1910, . .	80.9	81.3	72.8	69.1	71.6	75.4	70.3	76.3	82.7	75.0	78.7	78.4	76.0
1911, . .	78.8	77.6	73.2	65.2	72.2	74.5	70.7	77.5	82.4	79.0	73.5	77.3	75.2
1912, . .	81.3	78.4	80.3	77.2	78.5	70.0	71.5	78.3	84.0	74.9	77.2	75.4	77.3
1913, . .	79.0	74.5	79.3	74.4	73.0	68.4	70.5	74.2	80.2	79.2	74.0	81.2	75.7
Mean, .	76.9	77.9	74.6	67.8	68.9	72.4	73.3	76.8	78.6	75.0	75.7	76.5	74.6

Mean Per Cent. of Cloudiness from Tri-daily or Semi-daily Observations.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889, . .	55	40	63	55	42	53	54	43	65	60	68	61	55
1890, . .	52	66	66	50	59	50	56	57	59	64	47	53	57
1891, . .	61	59	55	49	54	47	54	58	50	54	50	51	53
1892, . .	63	55	45	42	66	50	35	53	29	46	58	45	49
1893, . .	52	57	46	55	55	58	44	45	46	40	49	54	50
1894, . .	53	53	55	53	52	54	50	44	53	44	50	44	50
1895, . .	51	39	55	54	46	48	58	44	42	42	61	45	49
1896, . .	43	63	54	39	40	47	50	40	52	63	59	42	49
1897, . .	46	51	56	46	47	47	64	42	39	39	71	68	51
1898, . .	66	64	53	68	65	57	53	60	48	62	60	66	60
1899, . .	53	58	66	42	54	54	50	57	47	60	53	52	54
1900, . .	52	62	47	46	54	49	48	49	54	64	72	62	55
1901, . .	58	45	68	75	70	48	63	67	51	48	65	65	60
1902, . .	60	63	66	68	58	62	66	50	57	51	62	60	60
1903, . .	61	53	63	50	36	71	52	63	42	58	41	49	53
1904, . .	55	42	57	52	45	59	55	47	54	42	43	57	51
1905, . .	58	31	46	43	56	61	55	56	48	36	42	56	49
1906, . .	51	44	49	49	47	54	53	50	32	52	53	66	50
1907, . .	58	41	44	33	68	50	42	36	64	30	48	51	49
1908, . .	37	42	48	42	50	28	47	45	27	37	46	49	41
1909, . .	61	60	49	52	56	44	33	35	55	49	56	45	50
1910, . .	60	57	49	56	66	59	34	47	55	44	68	55	54
1911, . .	62	55	49	42	55	54	42	61	53	59	60	63	55
1912, . .	55	36	53	64	64	43	46	50	60	40	51	58	52
1913, . .	63	42	62	55	53	35	39	41	47	63	53	45	50
Mean, .	55.4	51.1	54.6	51.2	54.3	51.3	49.7	49.6	49.2	49.9	55.4	54.5	52.2

Hours of Bright Sunshine by Sun Thermometer.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Possible hours,	294	296	371	402	453	457	462	429	373	341	293	283	4,454
1889, . .	134	183	138	191	270	277	182	194	120	129	84	108	2,010
1890, . .	112	131	160	245	225	264	289	199	166	129	143	131	2,194
1891, . .	126	124	195	240	226	248	222	204	224	150	141	143	2,245
1892, . .	128	138	196	244	183	218	287	201	234	178	101	144	2,261
1893, . .	130	111	172	166	188	209	259	225	185	182	133	112	2,072
1894, . .	120	121	150	174	208	180	237	237	176	160	128	159	2,051
1895, . .	153	187	172	188	243	246	192	251	254	197	111	169	2,363
1896, . .	157	168	210	258	297	263	260	254	189	115	105	172	2,448
1897, . .	144	154	188	239	236	248	214	274	221	209	90	108	2,325
1898, . .	132	138	200	168	200	270	236	201	218	157	126	113	2,159
1899, . .	151	147	134	280	221	235	259	206	200	140	130	142	2,245
1900, . .	167	120	216	227	235	259	260	226	177	136	86	108	2,216
1901, . .	117	172	93	103	159	254	208	160	215	178	100	107	1,866
1902, . .	120	138	143	139	210	179	185	209	149	164	109	119	1,864
1903, . .	114	145	138	199	311	102	247	169	236	154	182	129	2,126
1904, . .	144	173	172	182	256	256	274	292	204	183	148	115	2,401
1905, . .	119	178	216	247	286	247	263	242	186	209	156	128	2,477
1906, . .	128	183	225	269	288	316	278	266	254	189	155	111	2,660
1907, . .	130	200	245	268	209	217	297	217	110	177	125	122	2,317
1908, . .	154	200	220	277	282	362	308	268	242	186	111	133	2,743
1909, . .	127	157	232	220	263	300	290	241	192	194	146	148	2,510
1910, . .	119	180	275	286	287	279	371	229	245	229	137	156	2,793
1911, . .	145	132	236	296	320	280	297	227	195	124	74	105	2,431
1912, . .	149	180	224	198	214	314	260	238	156	163	146	148	2,390
1913, . .	179	205	182	211	221	312	324	282	182	91	113	121	2,423
Mean, .	137	159	189	221	224	253	260	228	197	165	122	130	2,304
Mean per cent., .	46.6	53.4	50.9	55.0	49.5	55.4	56.3	53.3	52.9	48.4	41.6	45.9	51.7

Precipitation (in Inches).

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889, . .	3.29	1.45	1.46	2.42	4.71	5.01	10.52	2.72	3.17	4.58	6.04	3.57	48.94
1890, . .	2.61	4.20	5.37	1.73	5.39	1.53	5.63	4.88	5.85	7.13	1.32	2.86	48.50
1891, . .	6.75	4.23	2.99	2.66	1.97	4.75	5.28	4.18	2.66	2.94	2.99	5.40	46.80
1892, . .	5.85	1.90	2.40	0.76	6.28	3.46	4.41	6.47	2.16	0.66	4.98	1.01	40.34
1893, . .	3.33	5.75	3.66	4.41	5.02	3.32	2.59	3.49	2.82	4.88	2.81	4.86	46.94
1894, . .	2.16	1.74	1.77	1.83	4.00	3.13	1.55	0.31	4.63	4.85	3.14	3.53	32.64
1895, . .	3.87	1.05	2.71	5.56	2.07	2.76	3.87	3.46	5.04	4.77	5.36	3.94	44.46
1896, . .	1.07	4.67	6.11	1.32	2.58	2.57	4.96	3.84	5.41	3.23	3.03	0.87	39.66
1897, . .	3.00	2.52	3.53	2.42	4.38	6.65	14.51	4.29	1.94	0.73	5.85	7.23	57.05
1898, . .	7.15	3.80	1.63	3.73	5.61	3.69	4.09	6.85	3.65	6.27	5.48	2.30	54.25
1899, . .	2.80	3.56	7.13	1.79	1.28	4.13	4.89	2.00	7.90	1.84	2.17	2.00	41.49
1900, . .	4.08	8.12	5.76	1.85	3.78	3.65	4.67	4.11	3.67	3.72	5.87	2.40	51.68
1901, . .	1.81	0.62	5.66	5.95	6.91	0.87	3.86	6.14	4.17	3.88	2.08	7.77	49.72
1902, . .	1.72	3.54	5.29	3.31	2.32	4.54	4.66	4.65	5.83	5.59	1.27	4.27	46.99
1903, . .	3.28	4.27	6.40	2.30	0.48	7.79	4.64	4.92	1.66	2.72	2.04	3.95	44.45
1904, . .	4.74	2.45	4.48	5.73	4.55	5.35	2.62	4.09	5.45	1.74	1.35	2.75	45.30
1905, . .	3.90	1.70	3.66	2.56	1.28	2.86	2.63	6.47	6.26	2.27	2.06	3.15	38.80
1906, . .	2.18	2.73	4.90	3.25	4.95	2.82	3.45	6.42	2.59	5.69	1.98	4.49	45.45
1907, . .	2.73	1.92	1.82	1.98	4.02	2.36	3.87	1.44	8.74	5.00	4.50	3.89	42.27
1908, . .	2.25	3.53	2.86	1.97	4.35	0.76	3.28	4.27	1.73	1.57	1.06	3.05	30.68
1909, . .	3.56	5.16	3.01	5.53	3.36	2.24	2.24	3.79	4.99	1.23	1.06	2.95	39.12
1910, . .	6.14	5.08	1.37	3.07	2.67	2.65	1.90	4.03	2.86	0.93	3.69	1.72	36.11
1911, . .	2.36	2.18	3.80	1.87	1.37	2.02	4.21	5.92	3.41	8.81	3.84	4.42	44.21
1912, . .	2.18	3.16	5.70	3.92	4.34	0.77	2.61	3.22	2.52	2.07	4.03	4.04	38.56
1913, . .	3.98	2.94	6.38	3.30	4.94	0.90	1.59	2.26	2.56	5.16	2.11	3.38	39.50
Mean, .	3.47	3.28	3.99	3.01	3.74	3.22	4.34	4.17	4.07	3.69	3.20	3.59	43.76

Wind Movement (in Miles).

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889, .	5,101	4,828	7,068	5,648	4,056	4,056	4,032	2,811	4,310	4,762	2,589	4,445	53,706
1890, .	4,914	4,616	5,395	5,032	5,284	3,776	3,976	4,116	3,507	4,143	4,228	5,673	54,648
1891, .	4,954	4,759	6,261	5,484	4,610	3,713	3,907	3,324	3,201	4,319	5,215	5,465	55,212
1892, .	5,059	3,438	7,046	5,370	5,056	4,500	3,365	3,390	3,672	4,071	5,231	4,522	54,720
1893, .	4,056	5,242	5,757	5,384	4,833	3,572	3,640	4,126	3,508	4,198	4,179	3,916	52,411
1894, .	4,193	4,865	4,406	4,105	2,180	1,838	1,109	1,920	1,414	2,540	4,179	3,508	36,257
1895, .	2,896	3,920	4,360	4,098	4,071	3,050	2,934	3,397	3,444	4,029	4,156	5,506	46,861
1896, .	4,943	6,445	8,182	4,674	4,838	3,926	4,048	2,968	4,686	4,544	4,654	5,290	59,198
1897, .	5,501	4,493	5,363	5,523	5,603	4,208	4,007	3,452	3,506	3,938	4,558	4,068	54,220
1898, .	3,494	3,699	3,864	5,477	4,769	4,162	3,377	3,111	2,787	3,999	4,856	4,830	48,425
1899, .	4,926	4,427	5,275	3,984	4,219	3,814	3,891	2,522	3,967	2,582	3,361	4,142	47,110
1900, .	4,904	5,016	5,602	5,039	4,381	4,101	3,701	2,322	3,042	3,315	4,877	4,203	50,503
1901, .	5,224	5,484	5,482	6,211	4,525	3,647	2,763	2,144	2,358	3,652	4,583	4,280	50,353
1902, .	4,078	5,199	6,601	4,642	4,328	4,102	2,929	2,386	2,680	4,398	3,077	4,018	48,438
1903, .	4,254	4,529	4,169	5,125	3,908	3,130	3,087	2,105	2,890	4,703	3,362	4,994	46,256
1904, .	4,112	4,910	4,444	4,902	3,830	3,127	3,268	3,232	3,602	4,160	3,470	3,940	46,994
1905, .	5,180	4,503	3,006	4,855	5,004	3,108	3,464	3,030	2,527	3,397	4,317	4,051	46,442
1906, .	5,706	4,565	5,686	4,777	3,766	1,409	3,773	3,412	4,249	4,398	5,978	5,554	53,273
1907, .	4,987	5,272	5,718	7,096	5,946	4,223	4,114	3,928	3,582	5,111	4,773	5,266	60,016
1908, .	7,770	5,511	5,759	8,208	5,818	4,571	3,815	3,802	3,757	3,643	5,485	5,432	63,571
1909, .	5,991	5,585	7,034	6,679	5,371	4,225	5,097	3,485	4,008	4,400	5,793	5,845	63,513
1910, .	5,786	5,834	5,579	5,533	5,289	3,685	3,812	4,271	3,336	5,467	5,215	5,435	59,242
1911, .	6,085	5,515	7,485	5,738	4,939	3,546	3,878	3,029	3,809	3,451	5,950	4,857	58,282
1912, .	4,872	4,798	5,291	6,094	5,332	4,533	3,992	3,698	2,980	3,953	5,037	5,337	55,897
1913, .	5,359	5,194	6,413	5,659	3,672	3,746	4,315	3,441	3,220	4,698	5,003	4,400	55,120
Mean, .	4,974	4,906	5,650	5,413	4,625	3,671	3,612	3,177	3,362	4,115	4,565	4,759	52,827

Maximum Wind Pressure (in Pounds per Square Foot).

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Maximum Annual.
1889, . .	26.0	24.0	16.7	15.5	9.0	11.5	10.0	6.5	9.7	12.2	14.5	29.0	29.0
1890, . .	27.7	17.5	13.5	11.5	16.5	10.0	9.2	13.0	5.0	11.0	9.5	24.5	27.7
1891, . .	16.2	13.5	10.5	14.0	10.7	10.5	4.5	2.5	4.0	9.5	15.7	14.0	16.2
1892, . .	10.5	11.5	20.5	16.7	15.7	20.5	11.5	7.5	15.5	12.5	16.0	13.5	20.5
1893, . .	12.0	20.0	18.5	24.5	24.7	9.0	13.0	37.5	14.5	23.0	14.0	18.5	37.5
1894, . .	20.0	22.5	11.5	15.5	14.5	14.0	9.5	9.5	13.0	10.0	18.0	15.0	22.5
1895, . .	13.0	25.0	20.0	10.0	7.0	8.0	8.0	5.5	43.0	14.0	22.0	24.0	43.0
1896, . .	15.0	24.5	19.0	18.0	25.0	7.7	8.5	12.5	19.0	12.0	15.0	12.0	25.0
1897, . .	18.5	10.0	13.5	14.0	22.0	7.0	12.0	14.0	20.0	11.5	20.0	12.0	22.0
1898, . .	22.5	15.5	15.5	10.0	18.0	8.5	17.5	13.0	30.5	12.0	19.0	28.0	30.5
1899, . .	20.0	15.0	22.0	9.5	10.5	7.5	12.0	5.5	6.5	6.5	11.0	15.5	22.0
1900, . .	20.5	30.5	16.0	13.0	22.0	12.5	23.0	16.0	17.0	10.0	18.0	13.0	30.5
1901, . .	12.5	10.5	10.5	13.5	11.5	7.5	14.5	2.0	24.0	9.0	17.5	14.5	24.0
1902, . .	12.0	24.0	24.0	14.0	10.0	15.0	7.5	8.0	4.0	8.0	9.5	12.5	24.0
1903, . .	12.5	22.0	8.0	12.5	9.5	9.0	15.5	3.0	7.5	3.0	9.5	17.0	22.0
1904, . .	11.0	23.5	14.5	15.5	11.0	6.0	11.0	6.5	14.5	23.5	11.5	9.5	23.5
1905, . .	23.5	18.0	16.5	18.0	9.5	6.0	9.0	7.0	7.0	9.0	9.0	14.0	23.5
1906, . .	8.0	8.5	7.0	10.0	7.5	5.0	6.5	4.5	4.5	9.0	8.5	12.0	12.0
1907, . .	14.0	20.0	27.0	12.0	6.5	6.0	32.5	4.5	6.0	9.0	8.5	18.5	32.5
1908, . .	16.0	23.0	10.0	32.0	13.0	7.0	10.0	4.0	9.0	9.0	9.5	7.5	32.0
1909, . .	8.5	18.5	18.0	27.5	8.0	7.0	7.0	3.0	5.5	8.5	13.0	14.0	27.5
1910, . .	15.0	15.0	11.5	6.0	7.5	4.0	6.0	8.5	2.5	8.0	7.5	10.5	15.0
1911, . .	19.0	9.5	21.0	9.0	7.5	5.0	7.5	3.0	5.0	6.0	15.0	30.5	30.5
1912, . .	19.5	23.0	6.0	10.0	13.5	8.5	5.5	6.5	3.5	5.0	18.0	10.0	23.0
1913, . .	18.0	13.5	23.5	16.5	5.5	4.5	27.0	4.5	6.5	23.0	14.5	7.0	27.0
Maximum,	27.7	30.5	27.0	32.0	25.0	20.5	32.5	37.5	43.0	23.5	22.0	30.5	43.0

Maximum Velocity of Wind (in Miles per Hour).

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Maximum Annual.
1889, . .	72	69	58	56	42	48	45	36	44	50	54	76	76
1890, . .	74	59	52	48	57	45	43	51	32	47	44	70	74
1891, . .	57	52	46	53	46	46	30	23	28	44	56	53	57
1892, . .	46	48	64	58	56	64	48	39	56	50	57	52	64
1893, . .	49	63	61	70	70	42	51	87	54	68	53	61	87
1894, . .	63	67	48	56	54	53	44	44	51	45	60	55	67
1895, . .	51	71	63	45	37	40	40	33	93	53	66	69	93
1896, . .	55	70	62	60	71	39	41	50	62	49	55	49	71
1897, . .	61	45	52	53	66	37	49	53	63	48	63	49	66
1898, . .	67	56	56	45	60	41	59	51	78	49	62	75	78
1899, . .	64	55	66	44	46	39	49	33	36	36	47	56	66
1900, . .	64	78	57	51	66	50	68	57	60	45	60	51	78
1901, . .	49	46	46	52	48	39	54	20	69	42	59	54	69
1902, . .	49	69	69	53	45	55	39	40	28	40	44	50	69
1903, . .	50	66	40	50	44	43	56	24	39	40	44	58	66
1904, . .	47	69	54	56	47	35	47	36	54	69	48	44	69
1905, . .	69	60	57	60	44	35	43	37	37	43	43	53	69
1906, . .	45	41	37	45	39	32	36	30	30	42	41	49	49
1907, . .	53	63	74	49	36	35	81	30	35	42	41	61	81
1908, . .	56	68	45	80	51	37	45	28	42	42	44	39	80
1909, . .	41	61	60	74	40	37	37	24	33	41	51	53	74
1910, . .	55	55	48	35	39	28	35	41	22	40	39	46	55
1911, . .	62	44	65	42	39	32	39	24	32	35	55	79	79
1912, . .	62	68	35	45	52	41	33	36	26	32	60	45	68
1913, . .	60	52	68	58	33	30	73	30	36	68	54	37	73

Snow, Frost and Weather.

YEAR.	Last Snow.	First Snow.	Total Snowfall (Inches).	Last Frost.	First Frost.	Number of Days of Precipitation.	Number of Clear Days.	Number of Fair Days.	Number of Cloudy Days.
1889, . .	April 2	Oct. 13	26.0	May 26	Sept. 21	119	94	110	161
1890, . .	April 8	Oct. 19	43.5	May 12	Sept. 25	141	137	105	123
1891, . .	May 5	Nov. 26	54.2	May 19	Oct. 12	112	145	103	117
1892, . .	April 10	Nov. 5	42.5	May 10	Sept. 30	108	123	109	134
1893, . .	April 21	Nov. 4	74.3	May 8	Sept. 3	143	101	96	168
1894, . .	April 12	Nov. 5	71.5	May 22	Aug. 22	125	107	83	175
1895, . .	April 3	Oct. 20	61.0	May 17	Aug. 22	119	118	110	137
1896, . .	April 7	Nov. 14	44.0	May 1	Sept. 24	108	132	192	132
1897, . .	April 27	Nov. 12	52.8	May 8	Sept. 22	127	108	109	148
1898, . .	April 6	Nov. 24	69.5	April 27	Sept. 21	125	78	138	149
1899, . .	April 16	Oct. 12	52.0	May 4	Sept. 14	110	91	139	135
1900, . .	April 9	Nov. 9	37.0	May 29	Sept. 15	131	83	144	138
1901, . .	April 3	Nov. 11	52.3	May 6	Sept. 26	135	81	105	179
1902, . .	April 2	Oct. 29	57.0	May 14	Sept. 6	144	73	113	179
1903, . .	April 4	Oct. 26	33.5	May 2	Sept. 25	116	119	98	148
1904, . .	April 20	Oct. 12	59.5	April 23	Sept. 22	126	142	96	128
1905, . .	May 1	Nov. 9	40.0	May 24	Sept. 12	122	130	128	107
1906, . .	April 23	Nov. 11	56.2	May 20	Sept. 25	121	130	140	95
1907, . .	May 11	Nov. 23	54.5	May 22	Sept. 27	122	95	155	115
1908, . .	April 20	Nov. 5	38.5	June 3	Sept. 16	109	143	130	93
1909, . .	April 9	Nov. 5	31.0	May 12	Oct. 13	128	112	151	102
1910, . .	Mar. 14	Nov. 8	44.5	May 6	Sept. 23	117	142	152	71
1911, . .	April 19	Nov. 14	35.0	May 5	Sept. 14	120	106	131	128
1912, . .	April 9	Nov. 3	33.8	May 1	Aug. 31	117	71	182	113
1913, . .	April 9	Oct. 31	26.5	May 15	Sept. 10	135	105	144	116

Summary for the Twenty-five Years 1889–1913, inclusive.

Barometer (Pressure in Inches).

Maximum reduced to freezing, Feb. 26, 1889, 11 A.M.,	30.650
Minimum reduced to freezing, Feb. 8, 1895, 7 A.M.,	28.240
Maximum reduced to freezing and sea level, Feb. 26, 1889, 11 A.M.,	30.970
Minimum reduced to freezing and sea level, Jan. 3, 1913, 7 A.M.,	28.550
Mean,	30.012
Total range,	2.420
Greatest annual range, 1913,	2.330
Least annual range, 1905,	1.640
Mean annual range,	1.890
Greatest monthly range, January, 1913,	2.180
Least monthly range, August, 1894,	.440
Mean monthly range,	1.100

Air Temperature (in Degrees F.).

Highest, July 4, 1911, 3.30 P.M.,	104.0
Lowest, Jan. 5, 1904, 7.30 A.M.,	−26.0
Mean,	47.5
Total range,	130.0
Greatest annual range, 1904,	120.5
Least annual range, 1906,	98.5
Mean annual range,	107.6
Greatest monthly range, January, 1907,	78.0
Least monthly range, August, 1901,	33.5
Mean monthly range,	54.6
Greatest daily range, Dec. 10, 1902,	54.0
Least daily range, June 2, 1907,	2.0

Humidity.

Mean dew point,	39.0
Mean relative humidity,	74.6

Precipitation (in Inches).

Total rain or melted snow,	1,093.91
Total snowfall,	1,190.70
Greatest annual precipitation, 1897,	57.05
Least annual precipitation, 1908,	30.68
Mean annual precipitation,	43.76
Greatest monthly precipitation, July, 1897,	14.51
Least monthly precipitation, August, 1894,	.31
Mean monthly precipitation,	3.65

Wind (in Miles).

Total movement,	1,320,668
Greatest annual movement, 1908,	63,571
Least annual movement, 1894,	36,257
Mean annual movement,	52,827
Greatest monthly movement, April, 1908,	8,208
Least monthly movement, July, 1894,	1,109
Mean monthly movement,	4,402
Greatest daily movement, April 8, 1909,	705
Least daily movement, Sept. 29, 1894, March 7, 1890, Jan. 6, 1904,	0
Mean daily movement,	145
Maximum pressure per square foot, 43 pounds, = 93 miles per hour, Sept. 11, 1895, 3 P.M.	

Weather.

Mean cloudiness observed, per cent.,	52.2
Total cloudiness by the sun thermometer, per cent.,	48.3
Number of clear days,	2,766
Number of fair days,	3,073
Number of cloudy days,	3,291

Gales of 75 or more miles per hour: 1889, Dec. 26, 76, N.W.; 1893, Aug. 29, 87, S.W.; 1895, Sept. 11, 93, N.E.; 1898, Sept. 7, 78, S.W.; Dec. 4, 75, E.S.E.; 1900, Feb. 22, 78, W.N.W.; 1907, July 20, 81, W.; 1908, April 11, 80, N.N.W.; 1911, Dec. 28, 79, W.N.W.

The following summary was abstracted from meteorological records taken in Amherst prior to the establishment of the meteorological observatory at the college in 1889.

The records from 1836 to 1883 are from the observations of the late Prof. E. S. Snell of Amherst College. These records were taken at his house, about one and a half miles south of the location of the meteorological observatory at the Massachusetts Agricultural College, and at practically the same elevation above sea level.

The precipitation records are believed to be fairly comparable with the records of this station, although perhaps slightly affected by the difference of topography surrounding the two places. As Professor Snell changed his time of taking temperatures, and used different methods of deducing the mean temperatures in conformity with the current practices at dif-

ferent dates, the comparison with those of this station should be made with more caution. The maximum and minimum temperatures of the earlier years were not all taken with self-registering instruments, and this fact should be taken into consideration when comparisons are made.

The records from 1883 to 1889 were taken at the State Experiment Station, on the college grounds, under the direction of Dr. C. A. Goessmann, at that time the director of the State Agricultural Experiment Station, and are fairly comparable with the records of this station.

Mean temperature for seventy-seven years: —

$$\frac{47.5 \times 25 + 46.7 \times 52}{77} = 46.9 \text{ degrees.}$$

Mean precipitation for seventy-eight years: —

$$\frac{44.36 \times 53 + 43.76 \times 25}{78} = 44.17 \text{ inches.}$$

Record of the Rainfall in Inches from 1836 to 1888, inclusive.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1836, . .	4.21	3.83	3.13	1.98	2.59	3.45	6.02	0.96	2.28	3.02	3.49	5.80	40.76
1837, . .	1.75	2.42	2.65	4.33	5.76	4.49	7.35	2.57	1.07	2.06	1.90	2.35	38.70
1838, . .	2.45	1.67	1.69	2.02	3.63	4.90	2.27	3.95	6.38	4.12	5.77	0.96	39.81
1839, . .	1.66	1.75	1.69	4.14	3.49	3.30	9.56	2.51	2.82	1.78	3.04	7.09	42.83
1840, . .	3.15	2.03	3.18	3.98	1.91	4.60	3.34	6.82	5.20	5.04	4.61	3.15	47.01
1841, . .	5.80	1.50	2.85	4.52	3.47	1.65	2.55	3.18	3.50	3.73	2.80	6.08	41.63
1842, . .	1.02	3.78	2.39	2.92	2.40	3.18	1.95	7.42	3.23	2.84	3.73	3.19	38.05
1843, . .	1.99	3.49	5.73	4.82	2.09	5.18	2.53	9.38	1.57	9.45	3.07	2.28	51.58
1844, . .	3.44	2.18	4.12	0.57	5.59	3.00	3.81	4.93	1.84	6.49	2.12	2.49	40.58
1845, . .	4.97	3.37	3.56	1.70	2.42	2.57	3.31	2.79	2.58	4.66	3.90	3.91	39.74
1846, . .	2.74	2.55	4.35	1.54	4.33	3.10	3.25	2.44	0.47	2.09	4.96	3.10	34.92
1847, . .	4.86	4.88	3.57	1.41	1.91	4.44	4.48	4.06	3.63	3.99	4.17	6.41	47.81
1848, . .	2.92	2.60	3.03	1.55	6.18	2.58	4.72	1.53	2.49	3.15	3.09	5.54	39.38
1849, . .	0.99	0.99	4.21	2.24	3.61	1.53	2.25	7.86	1.40	6.36	3.65	3.36	38.45
1850, . .	4.75	3.56	1.86	3.93	8.72	2.88	6.81	6.50	4.93	3.65	2.63	5.37	55.59
1851, . .	1.66	5.07	1.28	4.43	4.07	3.69	4.31	3.03	2.05	5.43	5.30	3.17	43.50
1852, . .	2.42	3.35	3.26	4.71	2.30	2.54	3.38	5.19	2.48	1.76	6.43	4.88	42.70
1853, . .	2.11	6.69	2.39	3.79	5.40	2.64	3.59	7.13	5.66	3.75	6.24	1.84	51.23
1854, . .	2.01	4.53	3.11	8.33	3.19	1.75	3.53	0.99	5.46	2.31	7.48	2.39	45.08
1855, . .	5.06	2.70	1.08	3.85	1.49	5.19	6.10	2.55	0.55	10.08	4.12	5.41	48.18
1856, . .	2.48	0.79	1.12	2.51	5.31	1.92	1.96	12.13	3.47	1.40	2.85	4.19	40.13
1857, . .	3.55	2.41	2.12	7.68	6.82	2.66	4.98	3.14	3.04	3.88	2.07	5.31	47.66
1858, . .	3.52	1.60	0.80	3.20	2.98	4.62	6.73	4.82	4.14	3.86	2.16	3.16	41.59
1859, . .	4.89	3.54	6.27	2.96	4.08	6.16	2.61	6.65	4.47	1.85	2.96	4.85	51.29
1860, . .	1.21	2.93	1.58	1.28	4.57	3.57	6.13	2.68	6.12	2.18	3.52	3.84	39.61
1861, . .	4.34	3.28	3.76	5.65	4.45	2.69	5.23	4.10	2.75	4.53	3.93	2.17	46.88
1862, . .	5.25	2.84	4.20	2.28	2.33	11.69	5.12	2.98	2.12	3.28	4.76	1.91	48.86
1863, . .	5.05	4.43	5.60	2.33	3.59	4.09	8.64	6.11	2.16	4.04	5.28	4.87	56.19
1864, . .	2.20	1.12	2.58	2.57	2.54	1.38	0.96	4.40	2.92	2.94	6.20	4.63	34.44
1865, . .	3.48	2.88	5.98	2.90	7.89	2.94	3.72	1.86	0.37	4.98	2.45	3.54	42.99
1866, . .	1.36	4.62	3.16	2.03	4.48	5.66	4.02	3.96	4.71	3.38	3.86	3.57	44.81
1867, . .	1.32	3.65	3.12	3.79	4.61	5.67	4.00	9.16	1.11	3.85	4.31	1.51	46.10
1868, . .	3.52	1.03	3.25	4.27	7.66	2.44	3.28	5.67	10.63	1.37	4.80	1.47	49.59
1869, . .	3.47	4.14	5.46	1.53	5.65	5.99	2.98	1.04	4.32	11.36	2.59	4.96	53.49
1870, . .	5.87	5.25	2.71	3.70	1.72	2.73	2.53	2.83	1.75	4.49	3.28	1.84	38.70
1871, . .	1.96	2.91	3.99	3.09	3.82	6.58	3.52	6.45	1.30	6.09	3.51	2.67	45.89
1872, . .	1.51	1.89	2.87	2.20	3.11	3.25	7.07	5.28	6.20	3.64	4.48	2.69	44.19
1873, . .	5.01	2.17	3.13	1.74	3.91	1.59	2.93	3.47	4.77	6.36	3.51	3.31	41.90
1874, . .	5.46	2.19	1.35	6.03	5.22	5.06	11.58	2.69	1.82	1.85	3.54	1.17	47.96
1875, . .	2.90	3.62	4.20	3.33	2.19	2.89	8.15	6.17	4.65	3.89	3.97	1.03	46.99
1876, . .	2.31	5.53	7.14	3.11	3.96	3.87	4.84	0.27	3.71	1.12	2.49	3.22	41.57
1877, . .	2.52	0.36	6.97	2.45	1.93	4.59	6.47	2.79	0.91	6.99	5.44	1.02	42.44
1878, . .	3.58	3.67	2.57	5.85	2.36	6.00	2.16	6.97	2.82	2.05	5.34	6.02	49.39
1879, . .	1.75	3.49	2.98	3.85	3.32	5.37	5.75	5.89	2.59	1.80	2.35	4.85	45.99
1880, . .	4.58	3.60	2.68	2.64	1.90	1.40	6.34	2.91	2.69	2.27	2.50	2.29	35.80
1881, . .	4.01	1.77	4.86	1.65	4.28	3.95	1.50	2.76	2.37	4.24	4.58	6.15	42.12
1882, . .	5.44	4.23	5.20	1.52	6.50	2.25	1.83	0.25	11.85	1.67	1.33	1.47	43.54
1883, . .	3.24	4.03	1.70	2.18	6.20	3.99	3.69	1.57	3.17	4.31	1.80	2.99	38.87
1884, . .	3.60	4.62	5.67	2.48	2.02	1.38	3.75	5.10	1.25	2.40	2.53	5.58	40.38
1885, . .	3.78	3.88	0.86	3.38	3.08	3.49	2.07	8.31	0.85	3.65	5.54	3.54	42.43
1886, . .	5.39	3.94	3.31	1.73	3.10	2.33	3.82	2.60	5.48	2.97	5.25	3.61	43.53
1887, . .	4.57	5.05	4.05	2.98	1.13	5.09	8.93	7.75	1.22	2.10	3.35	4.11	50.33
1888, . .	3.87	3.94	5.96	3.08	4.29	5.40	3.63	4.29	10.70	5.19	3.91	3.78	58.04
Mean, .	3.34	3.18	3.44	3.18	3.88	3.76	4.45	4.39	3.43	3.88	3.83	3.59	44.36

Record of the Mean Temperature from 1837 to 1888, inclusive.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1837, . .	20.3	26.7	33.7	47.4	57.9	68.2	70.6	68.6	61.4	50.0	40.2	27.6	47.7
1838, . .	32.0	19.6	36.4	40.7	54.3	68.6	71.9	68.2	62.7	46.5	34.1	23.5	46.5
1839, . .	24.6	29.8	37.5	52.2	60.7	65.4	74.4	70.7	63.5	53.3	36.6	28.9	49.8
1840, . .	14.4	28.5	35.0	49.0	57.1	65.5	70.6	70.3	57.2	47.4	37.0	23.6	46.3
1841, . .	25.6	20.2	31.9	41.6	54.4	68.4	69.5	69.8	61.2	42.8	35.3	29.5	45.8
1842, . .	25.6	30.5	37.7	46.5	52.7	64.1	71.5	69.0	57.4	47.4	35.1	24.2	46.8
1843, . .	29.7	16.5	24.5	44.6	56.0	65.3	68.8	69.8	61.7	45.0	34.0	28.0	45.3
1844, . .	13.9	22.1	35.5	52.0	57.8	65.6	68.2	68.0	59.6	47.6	35.7	27.3	46.0
1845, . .	24.5	24.9	36.9	45.6	56.2	66.7	72.1	71.5	58.3	49.6	41.5	21.5	47.4
1846, . .	24.8	20.1	36.3	50.1	58.3	65.0	70.7	69.6	65.5	47.6	43.0	25.3	48.0
1847, . .	25.5	24.7	29.2	43.3	57.5	64.7	72.4	69.3	59.3	46.0	43.2	34.2	47.4
1848, . .	29.0	23.7	32.6	43.3	59.5	67.6	69.4	70.6	57.4	47.3	33.5	30.6	47.0
1849, . .	20.0	18.5	35.6	43.5	53.4	66.9	72.1	68.8	60.0	47.0	44.1	28.4	46.5
1850, . .	25.9	28.4	32.4	42.9	53.4	67.3	72.1	67.1	59.4	48.2	40.0	23.4	46.7
1851, . .	23.8	27.9	35.5	46.2	55.6	69.6	69.2	66.2	60.9	51.0	34.5	20.2	46.2
1852, . .	19.6	25.2	30.9	39.4	56.0	65.4	70.0	65.2	58.4	49.3	36.4	32.8	45.7
1853, . .	24.3	26.7	33.8	44.0	56.7	67.0	68.7	67.8	59.5	46.8	39.1	26.3	46.7
1854, . .	22.8	22.0	31.6	43.5	59.5	66.7	74.1	68.8	61.5	51.5	40.3	22.3	47.0
1855, . .	27.3	19.8	31.5	43.8	56.6	65.0	70.9	65.5	60.8	49.7	38.8	28.2	46.5
1856, . .	15.2	19.0	25.9	46.4	53.6	68.6	72.9	66.2	60.8	48.7	37.5	23.2	44.8
1857, . .	13.5	31.4	31.1	41.0	55.2	63.6	70.9	67.2	59.9	48.9	39.5	31.5	46.1
1858, . .	28.8	20.6	31.3	44.4	54.1	66.1	69.8	67.9	50.9	51.4	33.9	25.7	45.4
1859, . .	22.9	25.6	36.7	43.4	59.2	62.8	67.7	66.4	57.1	45.7	41.1	23.0	46.0
1860, . .	26.5	24.8	37.2	44.0	57.3	65.2	66.4	68.0	56.8	48.8	42.7	23.9	46.8
1861, . .	20.4	29.2	32.5	45.5	53.4	65.5	69.5	65.7	59.9	51.5	37.8	29.0	46.7
1862, . .	22.3	22.1	32.2	43.6	58.1	63.4	68.0	68.1	61.1	51.0	39.6	27.6	46.4
1863, . .	29.1	26.3	26.1	45.5	55.4	59.0	70.9	70.1	57.4	49.9	41.1	25.3	46.3
1864, . .	24.4	28.5	34.4	43.5	60.4	65.7	71.5	70.8	57.8	46.4	38.0	38.2	48.3
1865, . .	18.7	25.0	37.1	49.0	57.1	69.3	69.1	68.6	65.6	46.0	39.9	28.9	47.8
1866, . .	21.9	26.2	31.6	48.6	54.6	65.8	72.9	63.5	60.0	49.5	40.1	26.3	46.7
1867, . .	18.3	31.2	30.8	45.5	54.0	67.1	68.1	68.6	60.0	49.9	37.9	22.6	46.2
1868, . .	20.2	18.2	33.8	42.0	55.1	66.2	74.0	69.0	59.5	45.3	36.5	22.8	45.2
1869, . .	28.0	28.0	27.3	46.4	55.9	64.7	69.1	66.9	62.1	46.7	35.9	27.5	46.5
1870, . .	30.8	25.3	30.9	48.3	58.3	70.4	73.6	71.1	62.3	52.0	39.1	28.0	49.2
1871, . .	23.3	26.0	40.5	48.0	57.8	65.4	69.2	68.9	52.8	51.0	34.0	24.6	46.8
1872, . .	25.1	24.2	25.3	45.0	59.1	68.1	72.6	71.6	61.7	48.2	36.4	19.5	46.4
1873, . .	20.6	24.0	30.6	43.2	54.6	67.5	71.3	67.0	60.4	49.9	29.7	29.2	45.7
1874, . .	28.2	24.5	32.9	38.3	56.5	66.2	67.2	65.6	62.0	47.6	36.2	29.2	46.2
1875, . .	16.7	17.5	27.8	40.8	57.1	65.8	69.3	68.9	57.3	47.9	33.1	28.3	44.2
1876, . .	29.8	26.4	31.6	43.6	57.5	70.6	74.2	70.5	59.1	45.5	40.5	19.7	47.4
1877, . .	20.0	30.8	33.3	47.8	58.5	67.8	71.1	71.4	63.3	50.5	41.9	33.1	49.1
1878, . .	25.3	27.1	39.2	52.2	57.4	64.7	73.3	68.6	63.2	54.4	39.1	29.0	49.5
1879, . .	21.6	22.4	33.0	43.2	60.6	66.3	71.0	67.2	59.0	56.0	37.4	30.8	47.4
1880, . .	31.6	29.1	33.5	47.5	64.2	68.5	71.8	67.5	63.2	47.3	34.9	22.8	48.5
1881, . .	17.9	24.9	36.2	43.6	61.7	62.8	70.6	70.5	67.4	52.5	40.3	36.0	48.7
1882, . .	23.6	28.2	35.1	44.3	52.9	66.8	71.9	70.9	63.2	52.7	36.4	26.6	47.7
1883, . .	21.0	25.0	27.3	44.3	58.6	69.7	70.4	66.4	59.4	46.8	40.4	27.0	46.4
1884, . .	21.6	30.9	32.9	46.7	57.4	69.0	68.6	69.2	64.4	50.3	38.4	30.0	48.3
1885, . .	22.7	15.2	23.3	45.3	54.8	63.8	70.4	66.0	58.3	49.1	39.8	29.6	44.9
1886, . .	21.8	35.1	33.5	50.4	57.3	63.2	68.8	66.3	59.5	48.9	38.3	23.0	46.2
1887, . .	19.4	24.2	26.4	41.6	60.9	65.7	73.7	64.9	55.9	47.0	36.5	26.6	45.2
1888, . .	13.8	22.0	26.8	40.4	54.7	65.8	67.2	67.4	57.1	43.1	38.9	30.4	44.0
Mean, .	23.0	24.7	32.4	45.1	56.9	66.1	70.7	68.3	60.1	48.7	38.0	27.0	46.7

Record of the Maximum Temperature from 1838 to 1888, inclusive.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1838, . .	55.0	42.0	58.0	67.0	80.0	90.0	92.0	88.0	85.0	77.0	57.0	43.0	92.0
1839, . .	50.0	50.0	65.0	72.0	80.0	84.0	86.0	85.0	80.0	70.0	56.0	53.0	86.0
1840, . .	38.0	56.0	64.0	79.0	88.0	88.0	94.0	90.0	77.0	72.0	55.0	44.0	94.0
1841, . .	50.0	44.0	60.0	67.0	81.0	90.0	94.0	88.0	84.0	64.0	68.0	44.0	94.0
1842, . .	37.0	55.0	68.0	82.0	78.0	84.0	90.0	82.0	84.0	70.0	60.0	43.0	90.0
1843, . .	50.0	37.0	42.0	70.0	82.0	86.0	91.0	84.0	87.0	69.0	57.0	40.0	91.0
1844, . .	39.0	49.0	56.0	83.0	84.0	86.0	86.0	84.0	83.0	70.0	54.0	45.0	86.0
1845, . .	46.0	55.0	71.0	77.0	88.0	90.0	94.0	89.0	81.0	74.0	65.0	38.0	94.0
1846, . .	45.0	40.0	59.0	76.0	83.0	87.0	93.0	90.0	88.0	81.0	61.0	45.0	93.0
1847, . .	44.0	47.0	52.0	77.0	84.0	88.0	91.0	85.0	85.0	67.0	70.0	59.0	91.0
1848, . .	56.0	43.0	64.0	74.0	86.0	90.0	87.0	87.0	81.0	70.0	52.0	58.0	90.0
1849, . .	46.0	43.0	60.0	68.0	83.0	92.0	93.0	83.0	70.0	68.0	63.0	43.0	93.0
1850, . .	45.0	52.0	60.0	70.0	73.0	90.0	87.0	87.0	80.0	67.0	63.0	49.0	90.0
1851, . .	48.0	48.0	73.0	67.0	82.0	88.0	87.0	83.0	80.0	73.0	56.0	44.0	88.0
1852, . .	43.2	47.4	53.0	61.0	79.0	84.0	90.0	85.7	85.0	70.0	50.8	56.0	90.0
1853, . .	45.0	51.0	56.4	76.3	84.2	91.3	85.1	91.7	84.7	69.0	59.5	42.8	91.7
1854, . .	50.4	45.0	65.4	70.6	79.0	87.5	97.0	88.5	90.0	75.8	66.0	41.5	97.0
1855, . .	48.0	42.0	57.8	76.0	81.0	92.0	91.6	84.5	85.0	73.0	63.0	46.2	92.0
1856, . .	34.8	38.6	44.9	76.7	89.0	94.0	95.0	87.3	78.9	75.5	61.0	41.8	95.0
1857, . .	37.1	61.8	54.5	58.3	86.4	86.9	90.3	90.3	85.7	73.0	67.0	52.0	90.3
1858, . .	51.4	47.1	57.7	68.1	74.2	90.3	92.0	79.0	85.2	73.0	59.0	42.8	92.0
1859, . .	39.4	44.1	56.6	71.0	86.0	91.5	90.0	81.8	73.8	75.0	65.8	62.9	91.5
1860, . .	50.3	52.0	71.3	68.3	81.0	83.0	84.0	84.4	79.0	69.9	66.7	37.5	84.4
1861, . .	38.0	53.5	56.3	80.3	77.2	84.0	91.7	90.0	82.3	75.5	64.0	51.4	91.7
1862, . .	42.9	40.0	44.5	72.9	84.0	86.0	90.0	88.0	80.0	83.0	68.2	52.0	90.0
1863, . .	52.0	45.3	47.3	77.0	88.0	85.6	85.5	90.0	80.0	71.0	65.4	51.5	90.0
1864, . .	44.2	46.8	53.8	64.8	86.0	93.5	91.9	98.0	80.0	68.7	62.0	49.4	98.0
1865, . .	39.5	45.4	63.7	79.5	85.8	87.0	85.4	90.0	89.0	72.0	68.0	54.9	90.0
1866, . .	40.0	55.0	55.8	84.2	80.0	90.1	94.0	81.6	83.1	73.0	60.8	51.2	94.0
1867, . .	33.5	50.0	53.0	66.0	75.5	85.0	90.0	83.5	80.0	76.0	65.0	46.0	90.0
1868, . .	39.5	45.0	59.8	67.5	75.0	88.7	94.5	85.0	79.5	68.0	58.0	42.7	94.5
1869, . .	49.0	50.6	53.8	74.0	83.0	80.7	89.9	87.2	85.0	71.4	56.9	45.3	89.9
1870, . .	54.3	55.0	50.5	78.0	82.4	93.0	91.2	91.3	83.5	71.5	61.0	47.0	93.0
1871, . .	50.0	50.6	55.5	74.8	92.8	88.2	85.6	85.0	78.0	73.1	62.0	43.3	92.8
1872, . .	42.9	50.0	44.0	84.0	84.1	91.8	91.7	88.8	88.5	69.0	54.0	40.3	91.8
1873, . .	42.3	45.0	49.3	66.2	82.0	90.0	92.4	86.2	85.8	70.5	52.0	57.7	92.4
1874, . .	52.0	49.3	57.2	63.0	86.0	93.0	90.0	84.0	85.8	66.0	60.0	49.0	93.0
1875, . .	35.5	50.0	51.0	63.0	84.7	89.0	91.5	84.8	84.7	70.3	56.2	55.0	91.5
1876, . .	63.0	52.3	59.0	63.3	86.0	87.7	95.0	90.0	90.0	71.1	71.7	42.0	95.0
1877, . .	43.0	50.0	52.8	75.8	84.5	88.0	89.1	87.4	85.7	75.4	66.8	55.2	89.1
1878, . .	44.4	53.3	65.1	73.1	83.2	90.2	92.2	83.3	84.5	77.3	57.2	53.7	92.2
1879, . .	50.1	43.2	51.6	72.4	83.0	90.3	91.4	90.6	85.6	82.6	68.2	54.5	91.4
1880, . .	47.9	57.6	59.8	77.7	93.0	91.1	90.5	88.0	90.0	71.4	59.2	38.9	93.0
1881, . .	38.0	47.0	50.8	78.4	89.0	80.0	87.2	90.8	94.0	86.2	66.7	61.4	94.0
1882, . .	45.0	47.4	56.2	68.0	78.0	90.0	92.1	93.0	87.7	73.8	66.1	48.0	93.0
1883, . .	42.2	43.1	51.1	67.3	89.0	90.8	93.0	86.2	79.8	77.1	67.2	53.1	93.0
1884, . .	40.1	46.0	54.0	70.3	85.2	92.5	93.0	92.4	90.0	78.2	61.0	57.4	93.0
1885, . .	57.0	39.0	50.0	83.0	85.0	89.0	93.0	87.0	81.0	80.0	70.0	65.0	93.0
1886, . .	56.0	52.0	61.0	83.0	82.0	82.0	95.0	90.0	83.8	77.9	65.5	49.0	95.0
1887, . .	47.2	43.8	46.0	74.4	86.5	91.0	93.6	88.0	80.0	74.4	64.8	51.0	93.6
1888, . .	41.0	49.0	49.0	84.0	80.0	94.5	85.5	87.0	76.0	66.0	71.0	56.5	94.5
Mean, .	45.5	47.9	56.3	73.0	83.2	88.6	90.7	87.2	83.2	72.9	62.1	48.9	91.9

Record of the Minimum Temperature from 1838 to 1888, inclusive.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1838, . .	6.0	—5.5	4.0	17.0	30.0	43.0	50.0	41.0	38.0	27.0	3.0	—7.0	—7.0
1839, . .	—13.0	0.0	4.0	22.0	27.0	40.0	49.0	44.0	34.0	22.0	11.0	—2.0	—13.0
1840, . .	—21.0	—14.0	7.0	19.0	34.0	44.0	50.0	50.0	36.0	23.0	18.0	—2.0	—21.0
1841, . .	—17.0	—6.0	8.0	21.0	29.0	43.0	42.0	42.0	46.0	20.0	13.0	5.0	—17.0
1842, . .	—10.0	5.0	13.0	17.0	30.0	34.0	49.0	45.0	30.0	26.0	13.0	—2.0	—10.0
1843, . .	—8.0	—15.0	7.0	15.0	35.0	34.0	47.0	53.0	30.0	28.0	17.0	2.0	—15.0
1844, . .	—22.0	—10.0	5.0	14.0	33.0	42.0	40.0	46.0	26.0	25.0	3.0	—5.0	—22.0
1845, . .	0.0	—3.0	8.0	24.0	30.0	41.0	46.0	42.0	32.0	17.0	12.0	—10.0	—10.0
1846, . .	—1.0	—6.0	2.0	22.0	32.0	41.0	44.0	47.0	37.0	25.0	20.0	1.0	—6.0
1847, . .	4.0	—8.0	9.0	5.0	34.0	42.0	46.0	48.0	35.0	15.0	5.0	3.0	—8.0
1848, . .	—12.0	—2.0	4.0	25.0	32.0	39.0	49.0	44.0	31.0	28.0	11.0	—3.0	—12.0
1849, . .	—8.0	—10.0	12.0	21.0	32.0	39.0	45.0	50.0	37.0	29.0	25.0	3.0	—10.0
1850, . .	—2.0	—11.0	8.0	19.0	31.0	44.0	48.0	44.0	32.0	23.0	16.0	—15.0	—15.0
1851, . .	—5.0	—8.0	12.0	24.0	30.0	41.0	49.0	39.0	29.0	31.0	13.0	—15.0	—15.0
1852, . .	—15.0	—3.4	0.3	23.3	38.5	43.9	55.0	48.9	33.0	24.3	15.0	6.1	—15.0
1853, . .	—2.5	0.5	7.6	27.4	31.8	39.0	54.0	45.9	37.0	24.9	13.8	7.2	—2.5
1854, . .	—9.6	—4.8	14.0	23.7	34.0	39.8	57.7	50.8	33.8	27.0	14.0	—9.0	—9.6
1855, . .	10.7	—16.0	7.8	17.0	41.5	48.0	57.2	44.7	33.0	30.2	15.0	7.0	—16.0
1856, . .	—7.5	—11.0	—9.0	16.5	38.2	48.0	55.9	48.2	41.8	25.0	18.0	—7.0	—11.0
1857, . .	—18.2	—2.7	7.0	14.3	39.8	49.0	55.5	53.6	32.0	25.0	13.0	2.2	—18.2
1858, . .	0.0	—5.0	—8.0	28.5	40.3	51.0	58.5	58.8	37.0	31.5	14.6	0.0	—8.0
1859, . .	—19.4	2.8	3.5	28.7	43.9	45.0	53.0	47.4	41.0	24.8	24.0	—8.5	—19.4
1860, . .	—8.0	—7.2	22.8	23.1	38.9	52.0	53.0	49.1	32.0	28.0	15.0	—7.0	—8.0
1861, . .	—17.0	—20.0	5.5	18.2	33.0	51.0	56.7	48.5	41.6	25.0	17.0	—6.5	—20.0
1862, . .	0.0	—2.0	13.8	24.3	44.0	49.5	51.9	48.0	39.0	26.0	18.0	—1.3	—2.0
1863, . .	5.0	—9.0	—6.0	25.0	38.3	51.0	55.3	48.7	32.0	21.0	18.0	3.2	—9.0
1864, . .	—1.5	—4.3	15.0	31.8	40.0	47.3	53.9	54.8	41.0	28.5	10.8	18.0	—4.3
1865, . .	—4.5	—1.0	13.0	33.0	42.8	55.9	54.8	47.5	35.0	24.2	18.5	6.8	—4.5
1866, . .	—14.5	—1.5	11.5	30.0	40.0	48.0	55.0	48.0	35.5	26.5	16.8	—3.8	—14.5
1867, . .	—5.0	8.0	8.0	29.0	36.0	54.0	55.3	48.3	39.0	27.0	17.5	—3.0	—5.0
1868, . .	0.0	—18.3	—7.3	23.0	36.0	51.8	61.0	51.0	36.2	19.2	23.8	—5.0	—18.3
1869, . .	3.0	—1.0	—9.0	26.7	35.2	47.4	53.5	50.0	36.3	26.8	16.9	—7.5	—9.0
1870, . .	5.0	6.2	6.5	35.0	42.8	53.5	54.5	47.0	40.0	26.0	24.7	1.0	1.0
1871, . .	—5.5	—9.5	24.8	27.0	41.0	51.8	54.0	50.0	32.0	24.3	7.0	—6.5	—9.5
1872, . .	2.5	—2.5	—4.8	29.0	43.7	48.7	59.1	52.9	39.5	29.9	10.0	—8.0	—8.0
1873, . .	—22.0	—2.5	1.8	33.5	39.0	50.6	56.1	49.1	36.2	27.0	6.5	7.0	—22.0
1874, . .	1.2	—5.0	9.7	18.7	39.0	51.3	38.0	46.3	39.0	28.5	16.0	0.0	—5.0
1875, . .	—8.2	—4.0	0.0	22.5	39.8	48.5	53.8	32.0	32.5	26.0	—1.0	—9.0	—9.0
1876, . .	2.8	—1.0	4.5	28.0	39.0	47.0	52.5	49.0	41.2	23.0	18.9	—1.0	—1.0
1877, . .	—3.5	8.5	10.0	32.5	40.0	54.7	58.1	54.8	39.0	25.3	19.4	13.0	—3.5
1878, . .	12.5	—3.2	13.2	37.0	40.5	46.4	55.2	49.9	37.0	27.0	19.8	11.7	—12.5
1879, . .	—4.5	1.0	7.0	32.7	40.0	49.0	56.7	53.2	30.4	20.8	7.7	—6.0	—6.0
1880, . .	2.0	—11.5	13.7	26.2	37.0	51.0	54.0	45.7	39.1	22.9	9.5	—5.0	—11.5
1881, . .	—12.4	—7.0	24.4	22.1	37.0	47.7	59.2	56.7	49.0	29.0	14.0	8.5	—12.4
1882, . .	—15.0	—6.0	17.4	23.7	39.1	52.2	56.3	49.7	43.7	32.2	12.0	0.0	—15.0
1883, . .	—2.5	—1.3	3.0	23.5	43.0	53.7	55.0	43.4	36.2	23.2	18.0	—12.8	—12.8
1884, . .	—8.0	5.1	0.0	31.2	37.6	50.0	57.1	48.8	39.0	26.5	19.8	—10.0	—10.0
1885, . .	—18.0	—15.0	—11.0	19.0	21.0	35.0	41.0	34.0	27.0	24.0	11.0	6.0	—18.0
1886, . .	—22.0	—11.0	—1.0	21.0	29.0	40.0	41.0	39.0	31.6	17.0	15.9	0.8	—22.0
1887, . .	—22.2	—3.8	—2.4	17.1	33.2	38.5	56.0	42.5	29.5	17.0	11.0	—6.0	—22.2
1888, . .	—21.5	—19.0	—3.0	15.0	26.0	38.0	46.0	42.0	25.0	26.0	5.7	3.5	—21.5
Mean, .	—7.4	—5.3	6.0	23.6	36.1	45.9	52.1	47.3	35.6	25.1	14.2	—1.3	—11.7

ALFALFA.

Since the methods of producing this crop, and the conditions under which it promises to be successful are not yet generally understood, it is the plan to present in this paper first, a brief general discussion of the characteristics and value of the crop; second, the results of the most recent experiments on the station grounds; third, results obtained by farmers who have been growing the crop in co-operation with the station; and fourth, brief general directions based upon long-continued experiments for starting and managing the crop.

Characteristics and Value of Alfalfa.

Alfalfa is an exceptionally deep-rooted legume, and under the best conditions it is long lived. Like other legumes it has the capacity, under the right conditions, of assimilating nitrogen from the atmosphere, but until the root system and the nodules which it bears are well developed its growth is greatly promoted by the presence of readily assimilable nitrogen in the soil. It is without doubt one of the most valuable forage plants known to man. It has long been cultivated in various parts of Asia and Europe, whence it was brought to Mexico by the Spaniards, who took it with them to California and the semi-arid portions of our southwestern States. During the past fifteen or twenty years its culture has been steadily pushed eastward, and it is now successfully grown in most parts of the United States and in a few parts of Canada. In many essentials and in feeding value alfalfa resembles the clovers; and as these are so generally known its characteristics will be perhaps best brought out by comparison.

Alfalfa compared with Clovers.

Longer Lived. — Alfalfa is a perennial, while individual plants of the red and alsike clovers, as a rule, live but two years. In regions without excessive rainfall, and in soils richly stocked with lime and thoroughly well drained, a stand of alfalfa is more permanent than a stand of clover under conditions existing in Massachusetts, but in this connection it is important to recognize two facts: —

1. That alfalfa in our soils and in our climate is much less permanent than in the west.[1] Experience everywhere indicates that the probability is that alfalfa will be gradually crowded out here by perennial grasses and clovers, most prominent among which are the Kentucky blue grass and white clover.

2. That it is possible to retain red and alsike clovers in permanent mowings without reseeding, provided a suitable system of top-dressing is followed.

Relative Yield. — Alfalfa grows more rapidly in early spring than either red or alsike clover, and starts more quickly after cutting, and accordingly it may usually be counted upon to give three crops during the season, whereas clover will usually give but two. The first cut of alfalfa is generally superior to either of the others. The total yield on good soils is likely to range from about 3 to 5 tons per acre of well-cured hay in the three cuttings, while red or alsike clovers on similar soils are likely to give about one-quarter less total yield in two cuttings.

Finer Stems. — The stem of the alfalfa plant is relatively finer than that of the red clover. It accordingly cures more rapidly and is usually more palatable, and is consumed with less waste than the coarser red or mammoth clover.

Nutritive Value. — It is popularly supposed, and quite generally stated, that alfalfa is much superior in nutritive value to clovers, but so far as can be determined by chemical analyses made in this station, and determinations of digestibility which have been made here in the department of plant and animal chemistry and in other stations, this does not appear to be the case.

[1] The winter of 1913-14 has proved very destructive (see p. 170).

Composition of Clover and Alfalfa Hays.

	Number of Analyses.	Water (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fiber (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
Alfalfa hay,	4	13.24	6.38	13.98	28.48	34.70	1.40
Alsike clover hay,	8	15.00	9.70	14.00	23.10	36.10	2.10
Medium red clover hay,	15	15.00	7.70	13.30	24.30	37.20	2.50

Digestible Nutrients and Energy Values.[1]

	Protein (Pounds in 100).	Fiber (Pounds in 100).	Nitrogen-free Extract (Pounds in 100).	Fat (Pounds in 100).	Net Energy Value (Therms).
Alfalfa hay,	10.2	13.9	24.4	.5	34.9
Alsike clover hay,	9.2	11.6	23.8	.8	34.6
Medium red clover hay,	7.7	13.1	24.2	1.4	35.6

It will be noted that alfalfa is relatively somewhat richer in digestible protein than the clovers, but considerably lower in fat. The net energy values, or in other words the productive food values, of alfalfa and the clovers are shown by the trials reported to have been substantially equal.

Soil Improvement.

It has been recognized since the time of the Roman empire, and was perhaps even before that period, that the growth of clover improves the soil, and that all crops give superior results when following it. This knowledge of the facts profoundly affected farm practice many centuries before the peculiarly beneficial effects of clover could be fully explained. We now know that they are a consequence chiefly of two causes: —

1. The penetration of the subsoil by the vigorous root system, opening, mellowing and enriching it.

2. The assimilation of large amounts of atmospheric nitrogen a portion of which remains in the roots and stubble even when the crop is harvested and removed. In both these respects

[1] Based upon average results in the United States.

alfalfa under the best conditions excels the clovers. Its roots penetrate more deeply, and the total crop residue — root and stubble — is greater.

The Soil for Alfalfa.

Alfalfa will thrive on soils of many different kinds, but whatever the type it must satisfy certain conditions: —

1. It should have good depth and be rich, especially in the mineral elements of plant food. Medium loams, inclining rather to be somewhat heavy than light, will give the best crops. The soils which contain too large a proportion of clay retain so much moisture that in open winters the crop, especially when young, is liable to heave.

2. Stagnant water in the subsoil is highly injurious. In soils with good capacity to conduct and retain water the presence of standing water in the subsoil (determined by sinking trial holes) within less than 5 or 6 feet of the surface will be highly injurious. If the subsoil be free from standing water to much greater depth it will be a distinct advantage. In the case of soils of coarser texture, which do not conduct water freely in large quantities, and which have deficient capacity to retain water, the water table may be nearer the surface without disadvantage, but even with such soils it would, doubtless, be inadvisable to attempt the cultivation of alfalfa with standing water nearer than 4 or 5 feet below the surface.

3. The field must have sufficient surface slope to carry off water, and there must be no pockets which will retain water. In fields which are too level, or in pockets, the formation of ice on the surface is fatal to alfalfa. It is, of course, possible that in this climate ice may sometimes form on the surface, even on considerable slopes, but this is a danger which cannot be avoided, and it is least on slopes.

4. The presence of a hardpan within less than 10 or 12 feet of the surface, or an excessively compact subsoil, will prove unfavorable; so, also, will a shallow soil underlaid by rock.

5. The soil must not contain free acid, though if this condition exists at the start it can be corrected by the use of lime.

6. The richer the soil naturally is in lime the better suited it is likely to be for alfalfa.


NO LIME
LIME

7. Where sweet clover grows abundantly wild, and where the beech tree occurs in large numbers, alfalfa will usually do well. This is because both sweet clover and the beech are lime-loving plants, and in the case of the sweet clover, moreover, because the bacteria which give it capacity to assimilate atmospheric nitrogen are either identical with those essential for alfalfa or so closely related that they serve the purpose. Inoculation for alfalfa is, therefore, unnecessary in sections where sweet clover grows spontaneously in abundance.

Lime Necessary.

Alfalfa, as already stated, is a lime-loving plant. The soils in many parts of this State are relatively deficient in this element. In most localities, therefore, an application of lime is one of the most important steps in the preparation of a soil for alfalfa. The quantity absolutely necessary will usually range between 1½ and 2 tons per acre; more will usually be beneficial. There are a number of different forms of lime which will serve the purpose. On the heavier soils freshly slaked lime, commercial hydrated lime or fine-ground quicklime will best meet requirements, since these forms of lime will both improve the mechanical condition and correct acidity. On the lighter soils, and especially if deficient in organic matter, air-slaked lime or fine-ground limestone may be preferable. The so-called agricultural limes, or waste lime, slaked in heaps at kilns will meet the requirements in most cases.

Manures or Fertilizers.

Manure. — While manure helps to give the soils the desired texture, and increases the proportion of humus, which may be beneficial, it usually carries weed seeds, and if applied shortly before seeding increases the difficulty of getting a good catch. The free use of manure will, moreover, be likely to increase the competition of grasses with the alfalfa, enabling these in a measure to gradually crowd the latter out. The application of manure in preparation for alfalfa is not recommended by the writer. On the other hand, a free use of manure for crops which precede alfalfa is desirable, especially on the lighter and poorer soils.

Potash. — Alfalfa, in common with clovers and other legumes, does well only when there is a liberal supply of potash in available forms in the soil. Potash fertilizers should be freely used in most cases in preparing for this crop. Potash in the form of sulphate, in the writer's experiments, appears much superior to potash applied in the form of muriate.[1]

Phosphoric Acid. — Although usually relatively less deficient in our soils as compared with the needs of alfalfa than lime and potash, it should be applied in some form, and among the different materials available basic slag meal seems usually to prove best, no doubt because it contains a large proportion of lime.

Nitrogen. — A large amount of nitrogen in the soil is not essential; from some points of view it is undesirable. To give the crop a good start, a fair amount of this element in available form in the soil is essential, but beyond that it is unnecessary and even harmful, — unnecessary because the alfalfa can draw nitrogen from the air, and harmful because it favors the grasses which may drive the alfalfa out.

Varieties.

There are a very large number of varieties of alfalfa now known. Many which may prove valuable have recently been introduced from Siberia by the South Dakota Experiment Station, but these are as yet insufficiently tested. There are but three kinds which deserve attention, known respectively as the common, the Grimm and the variegated.

Common Alfalfa. — This appears to be simply an unnamed strain. If from northern-grown seed, especially seed descended from generations of alfalfa grown in the north, it is fairly hardy and satisfactory.

Grimm. — A specially selected strain which originated in Minnesota; noted for hardiness and productiveness. It took its name from the farmer said to have been one of the most prominent in calling attention to the variety and promoting its dissemination. Comparative trials at this station and in many parts of the northern United States have indicated

[1] See page 157.

this variety to be superior in hardiness and in productive capacity to the common.[1]

Variegated Alfalfa. — This is said to be a cross between common alfalfa and yellow lucerne, a forage crop which is closely related to alfalfa. The flowers vary in color from yellow to greenish purple. This variety is said to be more hardy than ordinary alfalfa and adapted to poorer soils. Where either the common or the Grimm can be grown they are preferred to the variegated, which is characterized by decumbent growth, greater consequent tendency to lodge and lower feeding value. This variety has not been tested in the Massachusetts Experiment Station.

Obstacles to Success.

Diseases. — Relatively few diseases have proved troublesome in Massachusetts. The only important one is leaf spot, which is most injurious on newly sown areas. The spots, which usually appear first on the lower leaves of the plant, are yellow to dark reddish brown in color. Sometimes the lower leaves only are affected, in which case not much damage will be done, but in cases of bad infection, and under favorable weather conditions (hot, humid air and frequent showers), the trouble may spread rapidly; all the leaves turn yellow and gradually fall. In such cases the disease if unchecked greatly enfeebles the plants, and weeds, grasses or clovers tend to displace the alfalfa. No preventive treatment is known, but the disease can usually be checked and healthy growth re-established by cutting, and whether the alfalfa be young or old it should be promptly cut if the disease appears to be serious and rapidly spreading toward the upper leaves. If the field is newly sown and the crop only a few inches high the cutting should not be too close, and what is cut may be allowed to lie where it falls. If the new growth is not healthy the field should be recut. In the case of an established field the forage may be either made into hay or fed green.

Dodder. — This is a parasite characterized by abundant development of thread-like reddish-yellow stems, attached to

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[1] See page 156.

the stems of the alfalfa and bearing inconspicuous flowers of the same color. This parasite tends to spread rapidly; it renders the crop unpalatable. If noticed in the field it is best to cut the crop and burn it, plow the field and not put it into alfalfa again for a considerable number of years. Alfalfa dodder is not yet general in this State, and most energetic measures should be taken to exterminate it where it appears. If it shows in a field it is safe to conclude the seed of the dodder was mixed with the alfalfa seed. It is so fine it usually escapes detection by the average buyer. Dealers should be asked to guarantee alfalfa seed free from dodder. In cases of doubt samples of seed should be sent to the experiment station for examination.

Weeds. — Annual weeds will give but little trouble, provided such methods of seeding as are later recommended are followed. Especially is this true if the thorough preparatory tillage recommended when the seed is to be sown in late summer is followed. In the case of spring seeding, either with or without a nurse crop, annual weeds may compete with the alfalfa for water and food. If the growth is thick and rank the weeds may be clipped with a mowing machine set about 3 inches high. It is a mistake to sow alfalfa in fields heavily infested with the roots or seeds of perennial weeds. Especially is this true of witch grass, the competition of which alfalfa is wholly unable to withstand.

Grasses and Clovers. — In our better soils, and with our humid climate, some of the grasses and clovers, particularly Kentucky blue grass and white clover, tend to come in and gradually to crowd out the alfalfa. The tendency in this direction is increased by the use of barnyard or stable manures which, besides supplying large amounts of nitrogen (highly favorable to the growth of grasses), often carry their seeds as well as those of clover. It cannot be regarded as good practice to top-dress a well established field of alfalfa with manure of any kind. So doing, besides being objectionable from the points of view already stated, must be regarded as wasteful of nitrogen, the most costly plant-food element, since the alfalfa if well established is able to take this element so largely from the air.

It is possible, by the use of a harrow at the proper season, to in a measure check the coming in of grasses and clovers. These are more shallow rooted than alfalfa and may, therefore, be uprooted without much injuring the latter. A spring-tooth harrow properly set is the most effective type, and a special form of tooth has been designed for this particular use. This implement is advertised as the alfalfa harrow. Its use is most effective when the soil is relatively dry, and immediately after cutting either the first or the second crop will usually prove the best time for the operation.

Winterkilling. — Any one of the following causes may, under unfavorable conditions, destroy alfalfa: —

1. Heaving, which is most serious on the heavy soils. Tendency to this is much reduced by allowing a relatively heavy growth to remain in the field for winter protection. Perfect underdrainage, natural or artificial, of course lessens the tendency to heave, which is greater in proportion as the water content of the soil increases.[1]

2. Formation of ice on the surface. This is something which, under extreme weather conditions, may affect any field, but the tendency to this injury is comparatively small in fields where the slopes are such as to rapidly carry off surface water.

3. The presence of free acid in the soil, for this weakens the plant, rendering it susceptible to unfavorable conditions of any kind. The remedy is of course the application of lime.

4. Insufficient winter protection, due to too late cutting or excessive or overlate pasturing.

Recent Experimental Work with Alfalfa at this Station.

The more important of the recent experiments with alfalfa in this station have been as follows: —

1. Comparison of Grimm with the common alfalfa.

2. Comparison of high-grade sulphate with muriate as a source of potash.

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[1] Much alfalfa was killed during the year of 1913-14. The cause is not surely known; but it seems possible it was due in a measure to the large amount of water in the soil, owing to heavy fall and early winter rains (see p. 170).

3. Comparison of different methods of seeding.
4. A test of a commercial culture for inoculation.

In addition, we have had under constant observation a number of plots of different ages on which observations as to the gradual displacement of the alfalfa by grasses and clovers have been made.

1. *Grimm compared with Common Alfalfa.*

For a number of years it has been our object to make careful comparisons of the Grimm alfalfa with the common variety from northern-grown seed. Our first trials were begun in 1909, but although we obtained what we supposed to be Grimm seed of the very best quality from a grower recommended by the Minnesota Experiment Station, and believed to be absolutely reliable, our first experiments were a failure. There were no essential differences either in the appearance or the yield, and the party who furnished the seed later wrote us that a mistake had been made, that the seed sent as Grimm was not true to name. He supplied us, without charge, with seed of the genuine Grimm. This was sown after very careful preparation of the soil on a field where alfalfa had been previously grown in the late summer of 1911.

The land used in this experiment comprised two plots. Both have received annually for the past twenty-three years an application at the rate of 600 pounds per acre of fine-ground bone meal. One of the two plots has in addition annually received a liberal application of muriate of potash, for the last thirteen years at the rate of 250 pounds per acre; the other plot has annually received the same amount of actual potash, but in the form of high-grade sulphate, and for the last thirteen years at the rate of 250 pounds to the acre. Under both systems of manuring the Grimm alfalfa has given yields considerably larger than those obtained from the common. The results both for 1912 and 1913 are shown in the following table: —

Comparison of Varieties of Alfalfa and Source of Potash.

	Muriate of Potash.		High-grade Sulphate of Potash.	
	Grimm (Tons per Acre).	Common (Tons per Acre).	Grimm (Tons per Acre).	Common (Tons per Acre).
1912.				
1st cut, ...	2.122	1.56950	2.21875	1.98225
2d cut, ...	.465	.29075	.76925	.59150
3d cut, ...	.750	.63950	.94675	.82225
Totals, ...	3.337	2.49975	3.93475	3.39600
1913.				
1st cut, ...	3.08500	2.61600	2.94650	2.66250
2d cut, ...	.63935	.36045	1.00590	.71000
3d cut, ...	.40685	.29650	.57395	.50295
Totals, ...	4.13120	3.27295	4.52635	3.87545

The area of the plots used in these experiments is one-eighth acre each. The averages of both plots for the two years are: for the common alfalfa, 3.261 tons per acre; for Grimm alfalfa, 3.982 tons per acre, — a difference of about 22 per cent., greater yield in favor of the Grimm. In 1912 the yield of the Grimm alfalfa was 23 per cent. greater than that of the common. In 1913 both varieties yielded larger crops than in 1912, the yield of the Grimm being 21 per cent. greater than that of the common. The superiority of the Grimm as compared with the common is shown to have been no greater in the second year than the first. There is, therefore, no indication to date that the Grimm will prove more permanent than the other.

2. *Comparison of Potash Salts for Alfalfa.*

In one of the fields (Field B) of the experiment station grounds, the soil of which is a medium loam with compact and moderately clayey subsoil, alternate plots of one-eighth acre each have been continuously fertilized respectively with muriate and high-grade sulphate of potash in equal amounts for the past twenty-one years. These salts have been applied since 1900 at the rate of 250 pounds per acre each. Throughout the entire period (twenty-one years) these plots have each

had an annual application of fine-ground bone meal at the rate of 600 pounds per acre. Throughout this entire period no manure has been applied to the land, and no other fertilizer of any kind with the exception of lime. Hydrated lime at the rate of 2 tons to the acre was applied broadcast upon the rough furrow in April, 1910, and deeply worked in by the use of the disk harrow.

Two plots in this field were sown to common alfalfa on Aug. 2, 1910. The seed did not germinate well, and the growth being too thin the plots were plowed July 12 and reseeded Aug. 5, 1911. One-half of each plot was sown to Grimm alfalfa and one-half to the common northern-grown seed. The yields on the two plots are shown in the table, page 157. It will be noticed that in every case the yield obtained on the sulphate of potash has been materially greater than that obtained on the muriate. The average rates of yield per acre for the two years on the two potash salts have been as follows: —

	Muriate of Potash (Tons per Acre).	Sulphate of Potash (Tons per Acre).
Grimm alfalfa,	3.734	4.231
Common alfalfa,	2.886	3.636

Whenever the crop is in active growth (and this has been true almost ever since the little seedlings appeared above the surface) there is a striking difference in the shade of green of the foliage on the two potash salts. The leaves on the sulphate of potash plots are of a much darker shade, which would be characterized as dark green. Those on the muriate of potash plots are much lighter. The shade would be characterized as yellowish or pea green. A similar difference in shade of foliage has been noticed in the case of other plants when grown on these potash salts. It is believed that this indicates a difference in character or number of the chlorophyl bodies of the two types of plants, — a difference which we have not, however, been able to demonstrate by scientific tests, but which apparently gives the chlorophyl bodies of the darker green plants a higher degree of functional activity.

Bone and muriate.

Bone and sulphate.

3. *Spring and Summer Seeding compared.*

In the spring of 1910 a small area of silt loam soil, underlaid by gravel at the depth of 4 or 5 feet, was selected for the purpose of comparing the results of seeding in early spring with a nurse crop with the results of seeding in summer after bare fallow with sufficiently frequent harrowing to keep down weeds. The soil in question had been used during a number of years for a variety of crops including potatoes, corn and a test of varieties of alfalfa. Previous crops had been raised on fertilizers. No manure had been applied for many years. The soil contained a great many seeds of annual weeds, but it was not infested with the roots of perennial weeds. The entire field was limed on May 19 at the rate of $1\frac{1}{2}$ tons agricultural lime. On one-half of the field fertilizers at the following rates per acre were applied and harrowed in: —

	Pounds.
Basic slag meal,	1,500
High-grade sulphate of potash,	350
Nitrate of soda,	125

The spring sowing was made on May 19, with oats at the rate of 1 bushel per acre as a nurse crop. Fertilizers were applied to the other half on July 1, and the summer sowing was made on August 1.

From the spring-sown plot a fair crop of oats (somewhat mixed with weeds) was harvested in July, and in addition from this plot on September 21 was harvested a crop of alfalfa hay at the rate of 1.41 tons per acre. The yields from the two plots in the following year were as follows: —

Spring-sown alfalfa at the rate of 3.44 tons per acre.

Summer-sown alfalfa at the rate of 3.34 tons per acre.

From the statements so far made the conclusion must clearly be that the spring sowing had distinct advantages over summer sowing. We have first to its credit a fair crop of oat hay and a moderate crop of alfalfa the season of sowing; and second, the yield the following year was slightly greater than on the summer-sown alfalfa. There is, however, one point connected with the results distinctly unfavorable to the spring sowing, viz., the proportion of weeds in the product

was much greater than in the crop from the summer sowing. The weeds were not separated from the alfalfa the first year, and during the second year only from the second cutting. The method followed was this: just previous to the second cutting, one square yard in each plot, which seemed as a result of careful examination to be fairly representative in both cases, was selected, and the entire product cut and separated into three classes, viz., alfalfa, grass and clover, and weeds. The results reduced to a percentage basis are shown in the following table: —

	Spring-sown Alfalfa (Per Cent.).	Summer-sown Alfalfa (Per Cent.).
Total weight,	100	100.0
Alfalfa,	65	86.6
Grass and clover,	15	1.6
Weeds,	20	11.6

4. *Inoculation.*

Two experiments in inoculation by the use of a commercial culture have been tried. The first was upon land fertilized annually for a long series of years with bone meal at the rate of 600 pounds, and muriate of potash at the rate of 200 pounds, per acre (Field D). The land had been used for a considerable variety of crops. No alfalfa had previously been grown on it.

The soil is a medium loam with a compact subsoil containing considerable clay. The culture employed was Farmogerm [1] and it was used, in accordance with directions, for the treatment of the seed before sowing. In preparation for the crop the soil received an application of lime applied to the rough furrow (and deeply worked in) at the rate of 3,500 pounds per acre. The grade of lime used was a so-called agricultural lime containing some hydrate, but mostly in the form of carbonate. The land also received a mixture of fertilizers at the following rates per acre: —

[1] Farmogerm is made by the Earp-Thomas Farmogerm Company, Bloomfield, N. J. There are now numerous other commercial cultures on the market, and numerous colleges and experiment stations (this one among them) are now furnishing cultures for all legumes at cost to citizens of their respective States. No effort to compare the different cultures has been made in this station.

	Pounds.
Basic slag meal,	1,500
Muriate of potash,	500

This was deeply harrowed in. In addition, just previous to the last harrowing, a mixture of equal parts of nitrate of soda and fine-ground bone was applied at the rate of 500 pounds per acre.

The treatment of the soil brought it into a condition believed to have been highly favorable to bacterial activity; and the preparatory tillage had been such that it was moderately compact below, with the surface in fine mechanical condition and mellow. The seed was sown July 29. It germinated well and the ground was well covered, the crop being some 10 inches or more in height before cold weather set in.

The second experiment was upon a somewhat lighter soil (North Field) which would be characterized as a silt loam, underlaid with gravel of moderately open texture. This land had been annually manured for a considerable number of years with well-preserved manure from dairy cows. The rate of application had been moderately heavy. It had been used for a variety of forage crops in rotation, but no alfalfa had been grown upon it.

The preparation of the land and the general treatment were very similar to those in the other experiment. Lime was applied at the rate of 4,000 pounds per acre, basic slag meal at the rate of 600 pounds, and muriate of potash at the rate of 800 pounds per acre, and these were deeply incorporated with the soil by the use of the disk harrow. Just before seeding, a mixture of nitrate of soda and fine-ground bone meal in equal parts was applied at the rate of 400 pounds per acre. The seed was sown July 27, and as in the other field germination was perfect, and the ground well covered with abundant growth for protection during the first winter.

The seed used in both experiments was of two kinds: Montana-grown common alfalfa, and a variety which had been purchased under the name Grimm but which was later found not to have been true to name. It was, however, like the other, northern-grown seed; and the crops from the two kinds of

seed showed no appreciable differences. The rates of yield are shown in the following table: —

	Field D.			North Field.		
	Inoculated (Tons per Acre).	Uninoculated (Tons per Acre).	Gain per Acre.	Inoculated (Tons per Acre).	Uninoculated (Tons per Acre).	Gain per Acre.
1910.						
1st cut,	2.33	1.97	.355	2.70	2.44	.257
2d cut,	1.02	.88	.140	1.63	1.54	.090
3d cut,	1.43	.98	.450	1.41	1.39	.020
Totals,	4.78	3.83	.945	5.74	5.37	.367

It will be noted that in both experiments there was considerable gain due, in so far as can be judged, to the use of the culture. An examination of the roots at a number of different points in the early spring of 1910 showed, however, that there were nodules on the uninoculated as well as on the other, and in both cases by the end of the season there was no difference which could be detected by close observation in the appearance of the inoculated and uninoculated plots.

In 1911 the growth of the uninoculated was fully equal to that of the inoculated, and the weights were not separately taken. The value of the increase in the yield the first year, supposedly due to the inoculation, was, however, much greater than the cost of the culture ($2 for an acre) and the labor entailed in using it. The conclusion appears, therefore, to be justified that when alfalfa is put upon land on which the crop has never been grown the use of a commercial culture is likely to be profitable.

The rates of yield per acre on these fields in succeeding years are of interest in this connection. They show conclusively that on suitable soils rightly managed alfalfa is a valuable crop. The yields are shown in the following table: —

	Field D (Tons per Acre).	North Field (Tons per Acre).
1911,	2.72	2.80
1912,	2.99	3.58
1913,	3.89	4.97

The manurial treatment previous to the introduction of alfalfa in these fields, and the kinds and amounts of materials applied in preparation for the crop, have been given. Subsequent fertilizer treatment has been as follows: —

Field D. — From 1910 to 1912, inclusive, this was annually top-dressed with bone meal at the rate of 600 pounds, and muriate of potash at the rate of 200 pounds, per acre; and in 1913 the rate of top-dressing was basic slag meal 1,000 pounds, muriate of potash 200 pounds, per acre.

North Field. — This field received no top-dressing in either 1910 or 1911, but in 1912 and 1913 it was top-dressed with basic slag meal at the rate of 1,000 pounds, and sulphate of potash at the rate of 100 pounds, per acre.

In both fields the alfalfa is now considerably mixed with grasses, principally Kentucky blue grass and white clover. The yield, however, on both is still very large, and as both Kentucky blue grass and white clover rank exceptionally high in nutritive value the quality of the hay, though not pure alfalfa, is still much above the average in feeding value. An effort has been made to diminish the proportion of grass and check its spread in the North Field by thorough disking. This operation was carried out in the summer of 1912, immediately after the harvesting of the second crop. The result was a very material improvement.

Co-operative Experiments with Alfalfa

In Part I. of the twenty-third annual report the plans for the co-operative experiments now to be discussed were fully reported. These experiments were 33 in number. They were quite evenly distributed throughout the State, and were located on farms belonging to men especially recommended as well fitted for such work. The experiment station furnished the best obtainable seed. The soil was thoroughly prepared, the seed was inoculated with Farmogerm [1] and sown in the late summer of 1910. Three reports have been made by the farmers co-operating in this work.

The first of these reports was published in Part II. of the twenty-fourth annual report. This had reference to the conditions about the middle of May in 1911. Twenty-nine

[1] See page 160.

written reports only were received. The results may be classified as follows: successful experiments, 13; partially successful, 9; failures, 7.

Two other reports direct from the farmers have since been received: the first of these, made during the winter of 1912–13; the second, during the winter of 1913–14. On each occasion there was a diminished number of farmers responding, indicating, no doubt, failure on the part of most of those who did not report. The number of growers reporting in the winter of 1912–13 was 24. Of these, 6 were entirely successful, 8 partially successful and 10 had experienced failure.

At the time of the last report, in the winter of 1913–14, only 9 growers responded. Of these, 5 were successful, 1 partially successful and 3 had experienced failure.

The results obtained might be considered discouraging but for the fact that the causes of failure in most cases would seem to be avoidable. These causes, in the order of their importance, may be classified as follows: —

1. *Winterkilling.* — This appears to have been due in most cases to poor drainage or to too flat a surface, permitting standing water and ice. In some cases winterkilling seemed to be a consequence either of the fact that the seed was sown too late, or that the weather immediately following sowing was so dry that the crop did not get a good start. As a consequence of either of these conditions the first winter found the crop with insufficient growth for protection.

In other cases winterkilling was a consequence, also, of insufficient winter protection, but this was due either to the fact that the alfalfa was pastured too late in the fall or that the last cutting was made too late.

2. *Weeds and Grasses have crowded the Alfalfa out.* — This has occurred mainly on fields which either did not get a good start in the beginning, owing to imperfect germination of the seed, or on fields which were partially winterkilled, thus giving weeds and grasses opportunity to come in.

In some cases, however, the competition both of weeds and grasses with the crop has been accentuated by the use of manure as a top-dressing.

Among all the different weeds and grasses mentioned as

crowding out alfalfa, witch grass is the one most frequently mentioned. It is perfectly clear that sowing alfalfa in land infested with witch grass is highly unwise.

Yield obtained. — The range of yields in the successful experiments as reported by the growers (in part estimated) is from 1 to 6 tons per acre. This wide variation reflects the extreme differences in character of soil as regards physical characteristics and fertility, and also, no doubt to some extent, the difference in thoroughness in the work of the different farmers concerned. The average yield per acre of the 7 growers who reported definitely is 3.2 tons.

The Dates of Cutting. — There has been considerable diversity of practice, in spite of the fact that very definite advice was given, in the dates of cutting. The range has been about as follows: the first cutting from June 17 to June 28; the second, July 20 to August 20; the third, August 25 to September 25.

The Opinions of Growers. — The following is a list of the farmers who are co-operating in this work and a brief statement of their opinions as to the value of this crop for the section of the State in which they live: —

C. M. Cudworth (*Cummington*). — Consider it a profitable crop if clover and timothy can be kept out.

John H. Bartlett (*Nantucket*). — I think it is a valuable crop to raise. I am going to put in more this season.

Lovett Brothers (*Oxford*). — Have reseeded. New stand gives promise of a good crop.

C. W. Prescott (*Concord*). — The crop is holding its own and doing well considering that no plant food has been applied since planting. One-half acre seeded to Grimm has been a wonder.

Edward Kirkham (*Holliston*). — Crop has gradually died out. Shall not try it again on my heavy soil unless I do some tile draining.

Lyman P. Thomas (*Rock*). — Crop winterkilled because of the mistake made in pasturing too late.

Charles L. Clay (*North Dana*). — Still believe it to be a profitable crop if witch grass can be kept out.

Paul Cunningham (*Bolton*). — Crop was killed out by drought of 1911.

H. A. Parsons (*North Amherst*). — Results indicate crop to be valuable. Seeded 1⁹⁄₁₀ acres more.

Cyrus S. Bardwell (*Shelburne*). — Do not believe the crop is suited to this vicinity.

G. B. Trowbridge (*South Weymouth*). — The dry weather has a bad

effect upon alfalfa; at least it seemed to kill most of mine after the first crop was cut.

J. B. Sawyer (*Bradford*). — Crop suffered because of the severe drought in 1913.

Howard W. Foster (*Lowell*, R. F. D. No. 1). — Condition of the crop compared with a year ago is much better.

John L. Smith & Son (*Barre*). — If it were not for witch grass should sow the rest of the field.

H. K. Herrick (*Blandford*). — Results obtained are encouraging. Shall try more.

Selection of Seed.

The experiments described in earlier pages indicate that the Grimm[1] alfalfa is superior to the common, but the latter has given satisfactory results in many cases. Whatever the variety, it is important that northern-grown seed be selected for New England use; and not only that the seed purchased for sowing shall have been grown in the north, but it should be descended from as many generations as possible of northern-grown alfalfa. It will be wise, as already pointed out, to purchase only on guarantee that the seed is free from admixture with the seed of dodder.[2] Where this parasite becomes established success with alfalfa becomes impossible.

Time and Method of Seeding.

Alfalfa may be sown with success either in early spring with a nurse crop or late in summer with corn or alone. Sowing alone in late summer is attended with less risk than any other method.

Spring Sowing. — Alfalfa sown in spring will usually start well, but in order to keep down the annual weeds which are almost sure to be abundant in our better soils it is essential to put in a nurse crop; and at the season when this is cut the weather is frequently so hot and dry that the young alfalfa is seriously injured. When seeding in spring it is recommended that the quantity of alfalfa seed should be about 25 to 30 pounds per acre. Either oats or barley will serve best as a nurse crop, and about 1 bushel of either will be sufficient.

Seeding in Corn. — In some cases seeding to alfalfa in the standing corn according to the method of seeding to grass,

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[1] See page 156. [2] See page 153.

which is so commonly followed in the Connecticut valley has given successful results. This method, however, can be expected to succeed only when conditions are highly favorable. The soil must be one of fine texture, in perfect tilth, and naturally retentive of moisture. The corn field must be free from weeds, the corn must not be over thick, nor the growth excessively rank. If either of the last-named conditions exists the alfalfa will not make sufficient growth to go into the winter with adequate protection. If the corn is to be cut for the silo the alfalfa will be more likely to succeed than in field corn, for during the interval between the cutting of ensilage corn and cold weather it may make considerable growth. The best date for seeding in this manner is usually about the end of July. Showery weather should be selected if possible, and the quantity of seed should not be less than 30 pounds per acre.

Summer Seeding alone. — This method of seeding has given more uniformly successful results than any other which has been tried in the station or upon the college grounds; indeed, with proper preparation it has never failed. The following is a brief outline of the most successful practice: —

1. Plow the previous autumn, or in spring as early as the ground can be worked.

2. Apply a heavy dressing of lime to the rough furrow either in fall or early spring and disk in at once.

3. As early in the spring as weed seeds begin to germinate apply the following mixture per acre: basic slag meal, 1,500 pounds; high-grade sulphate of potash, 400 to 500 pounds; and disk it in.

4. Between the date of the last operation and the date of sowing the seed (which should not be later than the last of July) harrow about once in ten or twelve days.

5. When ready to sow the seed apply per acre nitrate of soda, 100 pounds, basic slag meal, 300 pounds, mixing them and harrowing in lightly.

6. Sow 25 to 30 pounds of seed per acre, inoculating it if alfalfa has not been successfully grown on the land before, and cover as you would grass seed.

7. Inoculation may be effected either by the use of a com-

mercial culture, a culture which will be furnished by the college, or the incorporation of soil from a successful alfalfa field with the soil of the field to be sown. Inoculation of the seed is usually least expensive and fully as successful as the use of soil, but if the latter method is adopted sow 300 or 400 pounds per acre. It should be spread (in cloudy weather if possible) and at once harrowed into the soil. Cultures are most effective when fresh. They gradually lose vitality on keeping, and in ordering, whether from a commercial house or the college, the date when the culture will be used should be specified.

8. However luxuriant and abundant the growth following summer sowing, whether in corn or alone, it will not be advisable in the severe climate of New England to cut or pasture the crop. Even if the growth be a foot to a foot and a half in height it is worth more left in the field, and will not interfere with the development of the crop or the harvesting thereof the following season.

Harvesting Alfalfa.

Whatever the stage of development alfalfa should be harvested as soon as the buds or suckers which start near the base of the plant are well developed. This will usually be when the alfalfa is in early bloom. If allowed to stand much beyond the period of early bloom the plants start slowly after being cut, and the total yield of the season will be relatively small. In every case, however, before cutting examine the stem close to the ground to determine whether the basal buds are starting to grow. Whenever the cutting of the crop is too long delayed the result is a decrease in the total yield of the season. The last cutting should never be so late that the crop will not make growth sufficient for winter protection, and experience leads to the conclusion that in this climate this should be at least some 6 to 8 inches in height.

After cutting, alfalfa should be allowed to lie, with possibly one turning, until it is wilted. It should then be put into windrows which, if the weather is bad, may need to be turned once, and later into cocks where it should be allowed to remain until cured. Hay caps should be used if possible. Should the time required in curing it exceed about five days the cocks

should be moved to avoid injury to the roots, and it is desirable, as in the case of clover (which is often similarly handled), to remove the caps and open or turn over the cocks on the morning of a good day, when it is judged to be sufficiently cured to be put in.

Top-dressing.

If the crop has been successfully inoculated, or if the nodules which have been referred to are abundant on the feeding rootlets of the alfalfa, it will not be necessary to top-dress with materials furnishing nitrogen, or at least if such materials are at all required (as may be the case upon soils which are naturally very poor and light) they should be used only in moderate quantities. If used freely, nitrogen stimulates the growth of grasses which, therefore, are all the more likely to crowd out the alfalfa. On the other hand, it is necessary in order to secure large crops that the mineral elements of plant food be accessible in abundance. If then the soil is not naturally richly stocked with phosphoric acid and potash these must be supplied, and the following mixture of materials is recommended annually per acre: basic slag meal, 800 to 1,200 pounds; high-grade sulphate of potash, 175 to 250 pounds; or low-grade sulphate of potash, 350 to 500 pounds. This mixture may be applied either in the autumn or in very early spring.

If basic slag meal is used as a source of phosphoric acid it is believed that a second application of lime will not be necessary, but if any other material is selected as the source of phosphoric acid a top-dressing with lime once in two or three years is likely to be beneficial.

Summary.

The following conclusions and advice appear to be warranted on the basis of the results obtained in the experimental work and practical experience of this institution: —

1. Alfalfa is superior to red and alsike clovers in holding the land longer, giving a somewhat greater average yield, and in fineness and palatability. The net energy value is about the same as that of good clover, but alfalfa hay is richer in protein and therefore better supplements corn silage, corn

fodder or corn and reduces the expenditure necessary for concentrated feeds.

2. Cultivation of alfalfa greatly improves the soil as a result, chiefly, of the deep penetration of its great tap roots and of the assimilation of atmospheric nitrogen which is left behind in large quantities in roots and stubble.

3. Alfalfa will thrive on almost all thoroughly drained soils, but the field should have considerable surface slope, and a soil rich in lime is best.

4. A heavy application of lime is in almost all cases necessary, usually from 1½ to 2½ tons at least.

5. On soils which are low in humus and relatively poor, one good application of manure plowed in is beneficial, but in general, fertilizers should be preferred to manure because less likely to bring in weeds, grasses and clovers.

6. The best source of potash for the crop is sulphate, and one of the best sources of phosphoric acid is basic slag meal.

7. The Grimm variety is superior.

8. Among the principal obstacles to success are leaf spot or rust, which can be prevented by cutting when it first appears; dodder, which can be avoided by care in the purchase of seed; the competition of weeds, grasses and clovers, which is reduced by avoiding manures or fertilizers rich in nitrogen; and winterkilling, which is due to poor drainage, formation of ice and insufficient growth for protection.[1]

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[1] Since this bulletin was written we have had opportunity to note the condition of alfalfa upon the station and college grounds in the spring of 1914. There is more winterkilling than for many years; and reports received from different correspondents indicate that the winter of 1913–14 has destroyed a large portion of the alfalfa in the State. A great deal appears to have been destroyed also in Connecticut.

The older seedings have in general suffered more than newly seeded areas; but in one case at least, reported by a large grower in Connecticut, the opposite was true.

The minimum temperature records were not exceptionally low, but from the middle of January until about the end of February the average temperature was low, and when lowest there was little snow protection. The principal known difference in conditions during the winter of 1913–14, and the winters of the recent years during which alfalfa has suffered little injury, was the higher proportion of water in the soil due to heavy autumn and early winter rains. It is the writer's belief that this was an important predisposing cause of injury. Alfalfa will endure extreme cold in relatively dry soils, but in soils containing a large proportion of water such temperatures subject its root system to most unfavorable conditions.

The Grimm variety has suffered far less than the common, even when the seed from which the latter was started was northern grown. In the light of existing conditions the writer's conviction is strengthened that our farmers will be wise not to depend too exclusively upon this crop. He would particularly urge that even although the seed be considerably higher in price, all farmers undertaking the growth of alfalfa should, for the present, plant Grimm variety, and as the demand for this seed is heavy and the price high he calls attention to the fact that there will be much temptation to substitute seed not true to name. The utmost care should be taken, therefore, to purchase only from parties known to be reliable.

9. The method of seeding attended with least risk is sowing alone in late summer after most careful preparatory tillage.

10. Inoculation of the seed is desirable when the crop is sown upon new land, and cultures used in accordance with directions are to be preferred to the use of soil in most cases.

11. In the co-operative experiments reported there is a large proportion of failures, but these appear to have been due to preventable causes, and the results are on the whole encouraging.

12. The crop should be cured with little exposure to direct sunshine and little handling to avoid loss of leaves.

13. It is a mistake to sow alfalfa in fields infested with witch grass.

14. The growth of weeds, grasses and clovers can be largely prevented by harrowing after the first or second cutting of any season when they are first present in noticeable proportion.

15. Annual top-dressing with slag meal and potash will in most cases be desirable.

COMPOSITION AND USE OF SOME OF THE NEW FERTILIZER MATERIALS; ALSO, FERTILIZING VALUE OF SOME LOCAL BY-PRODUCTS.

H. D. HASKINS.

In the large number of miscellaneous materials forwarded to the experiment station laboratory there occasionally appears a new fertilizing product or by-product of value to farmers living in the vicinity of the establishment which produces it. Oftentimes it may be a poorly balanced fertilizer, although if supplemented with chemicals or other fertilizing ingredients it may prove efficient. The large number of inquiries received regarding such products as sources of plant food would indicate the desirability of publishing a brief statement as to their use.

No. 1. Sheep Manure and Wool Waste.
No. 2. Wool Waste extracted of Grease (Sud Cake).

Analysis.

	No. 1.	No. 2.
Moisture,	4.99	44.80
Potassium oxide,	2.89	.37
Phosphoric acid,	.31	.03
Total nitrogen,	1.27	1.30
Water soluble nitrogen,	.51	.27
Active water insoluble nitrogen,	.30	.51
Inactive water insoluble nitrogen,	.46	.52
Approximate commercial value per ton,	$6 48	$4 00

Sheep Manure and Wool Waste (No. 1). — This manure, which is quite thoroughly dried, may be used at the rate of 4 to 5 tons per acre for corn; when used in seeding to grass,

this application should be supplemented by 500 pounds of basic slag phosphate. Some of the commercial sheep manures, particularly those from wool-carding establishments, often carry large quantities of noxious weed seeds.

Wool Waste extracted of Grease (Sud Cake) (No. 2). — This product would be more suitable for corn and to fit land for seeding to permanent meadows than for potatoes or other hoed crops. It can be used to advantage on all soils deficient in organic matter and humus. Five tons per acre may be used to good advantage for corn or seeding to grass. In addition it would be well to use 150 pounds of muriate of potash and 500 pounds of basic slag phosphate.

No. 3. Fine-ground Foreign Whale Guano.
No. 4. Rockweed.
No. 5. Crude Unground Garbage Tankage.

Analysis.

	No. 3.	No. 4.	No. 5.
Moisture,	–	15.66	64.89
Potassium oxide,	None	1.81	.11
Phosphoric acid,	9.90	.23	.81
Total nitrogen,	8.16	.60	.78
Water soluble nitrogen,	2.08	.09	.15
Active water insoluble nitrogen,	3.43	.15	.10
Inactive water insoluble nitrogen,	2.65	.36	.53
Approximate commercial value per ton,	$37 00	$3 35	$1 80

Fine-ground Foreign Whale Guano (No. 3). — Whale guano is quite similar in composition to dry ground fish. Its nitrogen availability is probably about 67.50 per cent., while that of fish averages about 70 per cent. The whale guano carries quite a high percentage of fat (13.82 per cent.), which will probably prevent its nitrogen from becoming as quickly available as that in fish scrap.

Rockweed (No. 4). — Rockweed may be used broadcast at the rate of 5 to 6 tons per acre, and thoroughly worked into the soil by means of a disk harrow. The use of lime with this material will ordinarily be found advantageous, — from one-

half to one ton per acre. The product carries but a small amount of phosphoric acid; the use, therefore, of 400 pounds of basic slag phosphate or acid phosphate per acre for crops such as corn and seeding to grass will usually be found both economical and effective. Rockweed may be used to advantage on any soil deficient in organic matter and humus. It is not a well-balanced fertilizer, however, and should ordinarily be supplemented by an application of some source of available phosphoric acid.

Crude Unground Garbage Tankage (No. 5). — Crude garbage tankage, undried and unground, is necessarily a coarse, slow-acting material; yet it has more than a local interest, as most of our cities having a population of 30,000 to 40,000 own municipal garbage-reduction plants, and a considerable tonnage of tankage is therefore annually produced. A considerable amount of this material is contracted for by the commercial fertilizer manufacturer who uses it as a conditioner in fertilizer mixtures after it has been dried and ground. In this condition it is, of course, worth much more as a fertilizer than in its crude state. Of late there has been considerable inquiry regarding the value of the product, and requests for analysis are not infrequent. In its natural state it may be worth cartage to farmers living in the vicinity of the plant. The product may be used like farm manures, — from 5 to 6 cords per acre would not be an excessive application. It should be thoroughly worked into the soil with a disk harrow, and ordinarily should be accompanied by an application of lime. From 400 to 600 pounds of basic slag phosphate and 100 to 150 pounds of muriate or high-grade sulfate of potash per acre should be used to supplement it.

No. 6. Calcined Phosphate.
No. 7. Calcium Cyanamid.
No. 8. Sewage Tankage.

Analysis.

	No. 6.	No. 7.	No. 8.
Moisture,	-	2.23	7.30
Potassium oxide,	.59	-	.03
Total phosphoric acid,	32.06	-	1.62
Available phosphoric acid,	26.32	-	-
Calcium oxide,	36.99	40.00	-
Iron and aluminum oxides,	6.66	-	-
Sodium oxide,	7.40	-	-
Total nitrogen,	None	14.33	5.26
Water soluble nitrogen,	None	12.99	.40
Active water insoluble nitrogen,	None	.41	2.38
Inactive water insoluble nitrogen,	None	.93	2.48
Approximate commercial value per ton,	$23 25	$54 45	$16 65

Calcined Phosphate (No. 6). — Calcined phosphate, as the name indicates, is a manufactured product, high calcination being a part of the process. It is represented to be made under the so-called Newberry-Fishburne process, which, briefly stated, is as follows: —

A 30 to 32 per cent. phosphate rock is mixed with 15 to 20 per cent. of an alkaline salt. The mixture is heated in rotary kilns to a high temperature. During the process most of the salt is volatilized. The resulting porous clinker is pulverized and ground to a fine condition suitable for a fertilizer. The product gives a mild alkaline reaction.

Unpublished results at the Ohio and Indiana Experiment stations indicate that this material furnished phosphoric acid in an available form. The writer has not heard of the product being generally quoted in the fertilizer trade, and its cost is therefore not known.

Calcium Cyanamid (No. 7). — Calcium cyanamid, now generally handled in the trade under the name cyanamid, although not a new product is but rarely used by the farmer except as a part of commercial mixed fertilizers in which it is now not infrequently used. It is said that most of it is now bought by the fertilizer manufacturers. In view, however, of the large

number of inquiries received concerning its nature, a short description may not be out of place.

Cyanamid is made by combining atmospheric nitrogen with calcium carbide at a high temperature, electricity being used as the heating agency. Two forms of cyanamid are now offered to the trade in this country, both being of a dark slate color. One is a fine powder, the other granular. The chemical composition of the two products seems to be about the same. The granular cyanamid possesses some advantages over the powdered form. It would be less dusty and disagreeable to handle, and probably could be used in larger proportions in mixtures with organic ammoniates and acid phosphates without causing loss of ammonia or serious reversion of the phosphoric acid. The nitrogen in cyanamid is largely soluble in water and in availability ranks well with sulfate of ammonia; it is not in the form of ammonia, however, but rather of an amide compound which is easily broken up in contact with water and becomes readily available in the soil. The product may be used as a quick-acting nitrogen source. Cyanamid may have an advantage over sulfate of ammonia in that it will not leave an objectionable acid residue in the soil as does the latter product. The residue left by cyanamid is a lime product which sooner or later will have a beneficial sweetening effect upon the soil. It would probably not be good practice to use more than 100 to 150 pounds of the cyanamid to the ton if the fertilizer mixture is likely to remain unused for a number of months. The free lime in the cyanamid will gradually cause a reversion of the soluble phosphoric acid. In the preparation of home-mixtures, which contain nitrate of soda, tankage, dry ground fish, blood, as well as other organic ammoniates, with acid phosphate and potash salts, a small proportion of cyanamid will be wisely included, as it favors the improvement of the mechanical condition of the mixture. It will aid materially in preventing the lumping of the fertilizer as well as the loss of nitrogen from the nitrate of soda under the influence of freshly prepared acid phosphate. These advantages will more than compensate any loss in the solubility of the phosphoric acid in the acid phosphate due to the action of the free lime in the cyanamid. This is particularly true if the proportion of cyanamid to the acid

phosphate is not greater than 1 to 8 or 10. Cyanamid should not be used in the same mixture with ammonium sulfate, as free ammonia will be liberated from the latter salt. It should prove a valuable source of quick-acting nitrogen for most crops, but is not recommended as a top dressing for grass. It will not be found injurious when applied unmixed at the rate of 200 pounds per acre as a source of part of the nitrogen for tobacco.

Sewage Tankage (No. 8). — Sewage tankage, as the name indicates, is a product recovered from sewage by means of the precipitation method. In the sample here reported the grease was extracted from the dried material, which was then ground to a good mechanical condition. The sample analyzed carried about 78 per cent. of organic matter. Products of this character vary greatly in composition, as two samples examined at this laboratory in 1912 showed only .32 per cent. nitrogen, the phosphoric acid running 6.67 per cent. and the potash .78 per cent. Such a product would be valued commercially at about $5.50 per ton.

It has not been found commercially profitable to extract the fat from sewage tankage. The unextracted material has a very slow action in the soil, and practical experience does not encourage its use.[1]

No. 9. Picker Dirt from Cotton Mill, Average of Three Analyses.
No. 10. Cocoa-shell Dust.
No. 11. Shoddy Dirt from Woolen Mill.

Analysis.

	No. 9.	No. 10.	No. 11.
Moisture,	6.95	11.09	4.95
Potassium oxide,	1.56	2.71	.68
Phosphoric acid,	.68	1.49	.20
Total nitrogen,	1.37	2.94	4.40
Water soluble nitrogen,	.24	1.04	.12
Active water insoluble nitrogen,	.27	.51	2.41
Inactive water insoluble nitrogen,	.95	1.39	1.87
Approximate commercial value per ton,	$5 50	$9 50	$11 00

[1] See Monthly Bulletin, State Board of Health, Vol. 8, No. 12, December, 1913.

Picker Dirt from Cotton Mill (*No. 9*). — Picker dirt varies somewhat in composition; 19 analyses made at this laboratory show the nitrogen to vary from 1.55 to 1.60 per cent., the potash from .48 to 1.62 per cent., and the phosphoric acid from .08 to .68 per cent. The average commercial value on the basis of these analyses would be $3.75 per ton. The product would be slow in action when incorporated with the soil. Probably the most economical manner of using the material would be to add it at frequent intervals to the manurial matter in the manure pit; when used in this way it would retain a large amount of liquid manure and prove of value both as an absorbent and as a direct furnisher of plant food. It would not be a suitable material to use in the stable gutters on account of the dust, which would have a tendency to irritate the air passages and lungs of animals, and also because of the danger in carrying the germs of contagious diseases. A moderate application of lime should be used on the soil with this product, also about 400 pounds of basic slag or acid phosphate and 100 pounds of high-grade sulfate of potash per acre. The material will be found better adapted to corn and seeding to grass than to most other crops, and may be used at the rate of three cords per acre. It should be plowed in.

Cocoa-shell Dust (*No. 10*). — Cocoa-shell dust carries considerably more plant food than do ground cocoa shells, testing nearly a per cent. higher in nitrogen and phosphoric acid. The material may be used at the rate of 1 ton per acre. It should be supplemented by an application of 100 pounds of muriate of potash and 300 pounds of basic slag phosphate or acid phosphate.

Shoddy Dirt from Woolen Mill (*No. 11*). — Shoddy dirt will be found to vary considerably in composition. It is not a well-balanced fertilizing material, as it carries too little potash and phosphoric acid in proportion to the nitrogen. It may be used at the rate of 3 tons per acre applied broadcast and thoroughly wheel-harrowed in. For corn and seeding to grass 800 pounds of lime, 500 pounds of basic slag or acid phosphate and 150 pounds of muriate of potash should also be used per acre. On poor soils 100 pounds of nitrate of soda may be used to advantage when seeding to grass.

No. 12. Lime Refuse from Manufacture of Lactic Acid.
No. 13. Lime Refuse from Bleachery Filter Bed.
No. 14. Lime Refuse from Tannery.

Analysis.

	No. 12.	No. 13.	No. 14.
Moisture,	46.00	16.87	35.93
Calcium oxide,	19.23	42.43	24.80
Magnesium oxide,	.44	1.30	3.10
Nitrogen,	.30	–	.42
Sulfuric acid (SO_3),	27.50	–	–
Carbonic acid (CO_2),	.98	34.00	4.44
Insoluble matter,	.68	–	16.37

Lime Refuse from Manufacture of Lactic Acid (*No. 12*). — Lime refuse from the manufacture of lactic acid would not be a fit material to use agriculturally until mixed with 200 or 300 pounds of limestone per ton of refuse. The raw product carries nearly one-half of one per cent. of free sulfuric acid, which would probably injure vegetation unless neutralized by the limestone. The value of the product would not be over $2 to $3 per ton at the farm. After receiving the application of limestone the product should be used the same as land plaster or gypsum, as most of the lime is present as sulfate.

Lime Refuse from Bleachery Filter Bed (*No. 13*). — This particular sample contained practically all of its lime in the form of carbonate. It gave only a slight reaction for chlorides. In ordinary practice it would be well to apply the material during late fall and allow it to remain exposed until spring, so that any injurious lime compounds that might be present would have a chance to oxidize before being mixed with the soil. It may be used in quantities up to 2 tons per acre on land in need of lime.

Lime Refuse from Tannery (*No. 14*). — Most of the lime in this sample was present as hydrated or slaked lime. The product carries nearly one-half of one per cent. of arsenic (As_2O_5). If the product be used in moderate quantities (2 tons per acre) this amount of arsenic would probably not prove

injurious to vegetation. It might, however, have a deleterious effect upon the beneficial soil bacteria. The sample has been submitted to the college bacteriologist, Dr. Marshall, who will later make some studies to decide this point. The opinion was expressed by Dr. Marshall that this small percentage of arsenic would not prove harmful when used as above specified.

In general, it might be said that these various refuse lime products, including the product from acetylene gas plants, may be used to advantage locally when they can be had for the hauling or at a small cost. It is usually the safest way to make the application of these products in the fall or winter, so as to allow a chance for the oxidation of any injurious compounds that may be present.

COCOANUT MEAL.

J. B. LINDSEY.

The cocoanut is the fruit of the cocoa palm (*Cocus nucifera*), growing in Ceylon, India, West and East Africa, the Philippine Islands, Brazil and Australia. It is valuable for its shell (which furnishes fiber), its oil and its meat. The milk in the inner part of the nut gradually becomes thick as the cocoanut ripens, and forms the meat of the nut. According to Ollech,[1] a typical ripe nut was found to consist of 30.45 per cent. of fiber, 19.59 per cent. of shell, and 49.96 per cent. of meat, and to weigh 1,133 grams. The oil is removed by pressure or by extraction by cooking with water, frequently at the place of production. The meat is shipped in a dry condition to Europe under the name of Kopra. The dry, unextracted meat (8 per cent. water) contains from 36 to 67 per cent. of oil.

The extracted meat is ground and furnishes the cocoanut meal used in animal feeding. When in normal condition it is light red to brown in color, has a nutty smell and taste, and is well liked by all kinds of farm animals.

The lot experimented with was secured from the Edible Oils Company of New York, who imported it.

1. Composition of Cocoanut Meal.

	Our Sample.	Average German Analyses.	Gluten Feed used in Experiment for Comparison.
Water,	9.00	10.50	10.40
Ash,	5.89	6.20	3.78
Protein,	19.35	21.40	23.37
Fiber,	8.64	14.70	6.82
Extract matter,	48.00	38.70	52.75
Fat,	9.12	8.50	2.88
Total,	100.00	100.00	100.00

[1] E. Pott, Handbuch d. Thierischen Ernährung, etc., Bd. III., p. 76.

Our particular sample contained rather less protein and fiber and more extract matter than the average of German samples. The latter, according to Kellner,[1] are sold on a guarantee of 18 per cent. protein and 12 per cent. fat. The gluten feed with which cocoanut meal is compared shows less ash and fat, rather more protein, and decidedly more starchy matter. The oil in the cocoanut meal very soon becomes rancid, and is converted largely into free fatty acids, giving a slightly unpleasant odor and taste.

2. Digestibility of Cocoanut Meal.

One experiment was conducted with two sheep, with the following results: —

	Our Sample.	Average German Analyses.	Gluten Feed for Comparison.
Dry matter,	–	80[2]	88
Ash,	64	–	88
Protein,	90	78	85
Fiber,	23	63	87
Extract matter,	87	83	90
Fat,	100+	97	81

Applying these coefficients to the analyses, we find the following amounts digestible in 2,000 pounds: —

	Cocoanut Meal (Our Sample).	Gluten Feed for Comparison.
Ash,	75.4	66.5
Protein,	347.6	397.2
Fiber,	40.4	118.6
Extract matter,	829.0	949.6
Fat,	187.4	46.6
Total,	1,479.8	1,578.5

It appears from the above results that the gluten feed furnishes about 100 pounds more digestible nutrients in 1 ton than the cocoanut meal. If, however, the fat in each case is con-

[1] Die Ernährung d. Landw. Nutzthiere, p. 359.

[2] Organic matter.

verted into its starch equivalent in the usual way, we find the cocoanut meal furnishes 1,705 pounds of digestible matter and the gluten feed 1,634 pounds. The cocoanut meal contains 88.4 therms of net available energy and the sample of gluten feed 82.7 therms. In case of gluten feed, Kellner requires a reduction of 10 per cent., making the therms 74.4 as against 88.4 for the cocoanut meal. It seems doubtful, however, to the writer if this 10 per cent. reduction is allowable. It hardly seems probable on the basis of composition and digestibility that the cocoanut meal would have a much greater nutritive value than would the gluten feed.

3. Feeding Experiment with Cocoanut Meal, 1911.

In order to test the relative efficiency of the cocoanut meal as compared with gluten feed as a component of a dairy ration, 10 cows were fed by the reversal method in periods of five weeks' duration. Hay and wheat bran constituted the basal ration to which were added definite amounts of either cocoanut meal or gluten feed.[1]

Table I. — *History of the Cows.*

Name.	Breed.	Age (Years).	Last Calf dropped.	Served.	Milk Yield (Pounds), Beginning of Trial.
Samantha,	Jersey-Holstein,	7	Aug. 15, 1910	Dec. 17, 1910	25
Amy,	Pure Jersey,	3	Sept. 20, 1910	Mar. 1, 1911	17
Gladys,	Pure Jersey,	7	Sept. 15, 1910	Aug. 14, 1911	21
May Rio,	Pure Jersey,	7	Dec. 5, 1910	Apr. 12, 1911	20
Betty,	Grade Jersey,	6	Oct. 22, 1910	Dec. 22, 1910	28
Betty II.,	Grade Ayrshire,	3	Dec. 8, 1910	Jan. 26, 1911	31
Fancy II.,	Grade Jersey,	3	Aug. 16, 1910	Dec. 22, 1910	18
Cecile,	Pure Jersey,	5	Nov. 1, 1910	Feb. 8, 1911	28
Ida,	Pure Jersey,	3	Sept. 5, 1910	Feb. 11, 1911	15
Red III.,	Grade Jersey,	5	Oct. 8, 1910	Dec. 14, 1910	28

[1] Cow Betty, being particularly thin, was given 1 pound of corn meal daily as a part of the basal ration in each half of the trial.

TABLE II. — *Duration of Trial, 1911.*

DATES.	Gluten Feed Ration.	Cocoanut Meal Ration.
January 6 through February 10,	Samantha, Amy, Gladys, May Rio, Betty.	Ida, Fancy II., Betty II., Cecile, Red III.
March 11 through April 14,	Ida, Fancy II., Betty II., Cecile, Red III.	Samantha, Amy, Gladys, May Rio, Betty.

An unusually long time elapsed between the two halves of the trial (four weeks). This was due to the fact that several cows in the herd suffered a severe attack of scours, the cause of which could not be determined. It naturally interfered with the accuracy of the trial, although all of the cows were in good condition when the second half started, March 11. They had shrunk, however, rather more in yield than they would have had they not suffered the attack. Cows Amy, Betty II., Cecile and Betty were particularly affected.

Care and Feeding of Animals.

They were kept in roomy stalls, carded daily and turned into a protected barnyard for three to five hours each pleasant day. They were fed twice daily; the hay was given some time before milking in the afternoon and the grain just before milking, while in the morning the grain was given just before, and the hay just after, milking. Water was supplied constantly by aid of a self-watering device.

Character of Feeds.

The hay was largely Kentucky blue grass with considerable sweet vernal grass and some clover (early cut). During the last half of the trial the supply of this grade of hay became exhausted, and a mixture of timothy, red top and clover was substituted. It was of very good quality, but not as appetizing as the other variety. The animals refused some of the coarser parts and showed a tendency to shrink in milk. The bran was of the spring variety, and the gluten feed of good quality.

Weighing the Animals.

Each cow was weighed for three consecutive days at the beginning and end of each half of the trial, before the afternoon feeding.

Sampling Feeds and Milk.

The hay was sampled at the beginning and end of each half of the trial in the usual way, as described in other experiments of this character. The grains were sampled daily and the samples preserved in glass-stoppered bottles and brought to the laboratory at the end of each half of the trial for dry-matter determinations and complete analyses.

The milk of each cow was sampled daily for five consecutive days on the first, third and fifth week of each half of the trial. The usual method of sampling was followed.

TABLE III. — *Analysis of Feedstuffs.*

	Water.	Protein.	Fat.	Nitrogen-free Extract.	Fiber.	Ash.
Hay,	9.97	8.04	1.71	44.47	30.84	4.94
Bran,	11.97	16.10	1.36	55.99	9.23	5.33
Gluten feed,	10.28	23.39	2.88	52.82	6.83	3.79
Cocoanut meal,	6.49	20.05	15.07	44.98	8.43	5.06
Corn meal,	12.89	8.69	3.31	72.07	1.78	1.25

TABLE IV. — *Total Rations consumed by Each Cow (Pounds).*

Gluten Feed Ration.

	Hay.	Bran.	Gluten Feed.	Corn Meal.	Cocoanut Meal.
Samantha,	908	140	140	-	-
Amy,	625	105	140	-	-
Gladys,	695	105	140	-	-
May Rio,	695	105	105	-	-
Betty,	900	105	140	35	-
Ida,	689	105	105	-	-
Fancy II.,	522	100	100	-	-
Betty II.,	690	175	140	-	-
Cecile,	689	138	138	-	-
Red III.,	797	140	140	-	-
Totals for herd,	7,210	1,218	1,288	35	-

TABLE IV. — *Total Rations consumed by Each Cow (Pounds)* — Concluded.

Cocoanut Meal Ration.

	Hay.	Bran.	Gluten Feed.	Corn Meal.	Cocoanut Meal.
Samantha,	790	140	-	-	140
Amy,	514	99	-	-	133
Gladys,	624	105	-	-	140
May Rio,	672	105	-	-	105
Betty,	711	105	-	35	140
Ida,	764	105	-	-	105
Fancy II.,	481	105	-	-	105
Betty II.,	746	175	-	-	140
Cecile,	793	140	-	-	140
Red III.,	840	140	-	-	140
Totals for herd,	6,935	1,219	-	35	1,288

TABLE V. — *Average Daily Ration consumed per Cow (Pounds).*

CHARACTER OF RATION.	Hay.	Bran.	Gluten Feed.	Cocoanut Meal.	Corn Meal.
Gluten feed,	20.6	3.48	3.68	-	1[1]
Cocoanut meal,	19.8	3.48	-	3.68	1[1]

The cows averaged .8 of a pound of hay more daily while on the gluten feed ration. This may have been due to the presence of the extra oil in the cocoanut meal satisfying the appetites. The different animals received from 16 to 26 pounds of hay, from 3 to 5 pounds of bran and from 3 to 4 pounds of gluten feed or cocoanut meal daily.

TABLE VI. — *Digestible Organic Nutrients in Average Daily Rations (Pounds).*

CHARACTER OF RATION.	Protein.	Fiber.	Extract Matter.	Fat.	Total.[2]	Nutritive Ratio.
Gluten feed,	2.10	4.13	8.70	.32	15.95	1:6.5
Cocoanut meal,	1.92	4.00	8.12	.75	15.69	1:7.2

[1] For cow Betty only; not included in figuring average digestible nutrients.
[2] Including fat × 2.2.

It would appear, on the basis of the above calculations, which were made by applying average digestion coefficients to average daily rations consumed, that the two herds received substantially like amounts of total digestible nutrients. The cocoanut meal ration contained rather more fat and somewhat less extract matter than the gluten feed ration.

Herd Gain or Loss in Live Weight (Pounds).

Character of Ration.	Loss.
Gluten feed,	8
Cocoanut meal,	79

The difference is not of great importance. During the gluten feed period the 10 cows showed a total loss of 8 pounds, and during the cocoanut meal period a loss of 79 pounds. Cows Cecile and Betty II. were milking their maximum while in the cocoanut meal period, which took some flesh from their bodies.

Total Yield of Milk Products (Pounds).

Gluten Feed Ration.

	Total Milk.	Daily Milk.	Total Solids.	Total Fat.	Butter Equivalent (Fat+⅙).
Samantha,	876.3	24.8	135.74	54.59	63.69
Amy,	608.8	17.4	91.81	35.55	41.48
Gladys,	731.8	20.9	112.99	44.93	52.42
May Rio,	741.8	21.2	111.72	43.84	51.15
Betty,	902.8	25.8	128.65	45.05	52.56
Ida,	447.8	12.8	75.95	32.60	38.03
Fancy II.,	537.9	15.4	74.93	27.33	31.89
Betty II.,	827.2	23.6	115.89	39.54	46.13
Cecile,	793.5	22.7	113.39	39.91	46.56
Red III.,	810.5	23.2	113.31	44.33	51.72
Totals for herd,	7,278.4	20.8[1]	1,074.38	407.67	475.63

[1] Average daily yield.

Total Yield of Milk Products (Pounds)—Concluded.

Cocoanut Meal Ration.

	Total Milk.	Daily Milk.	Total Solids.	Total Fat.	Butter Equivalent (Fat+1/6).
Samantha,	698.8	20.0	110.62	47.10	54.95
Amy,	482.8	13.8	73.63	31.29	36.51
Gladys,	579.6	16.6	86.59	35.76	41.72
May Rio,	592.3	17.0	91.63	38.14	44.50
Betty,	720.3	20.6	103.72	38.68	45.13
Ida,	525.3	15.0	90.40	40.97	47.80
Fancy II.,	583.5	16.7	82.86	32.56	37.99
Betty II.,	1,124.8	32.1	155.00	56.46	65.87
Cecile,	991.5	28.3	145.65	56.22	65.59
Red III.,	902.3	25.8	129.48	54.68	63.79
Totals for herd,	7,201.2	20.6[1]	1,069.58	431.86	503.85

The 10 cows produced substantially the same amounts of milk and milk solids on both rations. In the case of the total milk fat the difference is somewhat in favor of the cocoanut meal ration (nearly 6 per cent.). This may have been due to the influence of the oil in the cocoanut meal.

Adverse Influences.

1. The attack of scours between halves.
2. The feeding of a new lot of hay during the last two weeks of the trial. The hay, however, was fed to each of the 10 cows so that all were treated alike.
3. While like amounts of gluten feed and cocoanut meal were fed to each herd the cocoanut meal contained 6.49 per cent. of moisture, while the gluten feed contained 10.28 per cent. During the entire experiment, therefore, the cows received 50.2 pounds more dry matter (.14 pound daily) in the form of cocoanut meal than in the form of gluten feed.

Inasmuch, however, as the cows ate rather less hay while receiving the cocoanut meal, and as the total digestible nutri-

[1] Average daily yield.

ents fed were slightly in favor of the gluten feed ration, it is probable that the small excess of cocoanut meal was without influence on the results.

General Conclusions.

1. Cocoanut meal is of the same general type of composition as gluten feed. It contains more fat, ash and fiber and noticeably less carbohydrate matter.

2. Cocoanut meal was found to contain about 100 pounds less digestible matter in a ton than the gluten feed. By converting the fat of the cocoanut meal into its starch equivalent, however, its nutritive value would be rather above the gluten feed. One hundred pounds of cocoanut meal contained 88.4 therms of net available energy as against 82.7 therms for the gluten feed. This is clearly due to the higher percentage of fat in the former.

3. Our feeding experiment with 10 cows shows substantially the same results in the amount of milk from the cocoanut meal and gluten feed ration; slightly more butter fat was secured on the former ration.

It is believed that the cocoanut meal is fully equal to the gluten feed in nutritive value, although it is doubtful if it exceeds it. German observers consider it particularly desirable for dairy animals in amounts of from 3 to 4 pounds daily per head, and it has been shown to somewhat increase the fat content of the milk. Fed in excess of the above it is held to make too hard a butter.

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